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TREATMENT OF BURNS WITH CHEMOTHERAPEUTIC MEMBRANES

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The present day treatment of burns, particularly their emergency handling in large numbers of cases under conditions encountered in warfare, leaves much to be desired.

This paper deals with the local treatment of second degree burns, in which by definition the epidermis is not completely destroyed but in which the lesion may involve all the superficial layers down to the stratum germinativum from which the mature epithelium originates. Third degree burns present another problem; obviously if the epidermis is completely destroyed, the wounds must heal by granulation or second intention and therefore probably require some form of grafting.

Most of the widely used methods of treating burns have as their object the formation of an eschar over the burned area beneath which healing and epithelization can take place. This eschar is usually produced by repeated application of solutions of various drugs or drug combinations with the common property of coagulating proteins, e. g. tannic acid, silver nitrate, gentian violet (methylrosaniline). While some of them have bacteriostatic properties, it is necessary to start with a clean uninfected surface adequately prepared surgically if infection beneath the eschar is to be precluded.

Recently, an improvement in this therapy has been made by Pickrell [1] with the development of a water-triethanolamine solution of sulfadiazine (2-[paraaminobenzenesulfonamido]-pyrimidine) containing methylcellulose. With this solution no coagulation of proteins takes place. The

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1. Pickrell, K. L.: Personal communication to the authors.

eschar is formed by the precipitated methylcellulose and built up to the required thickness by repeated sprayings. The sulfadiazine reduces the incidence of subescharotic infection.

The objection to all of these methods of treatment is twofold. One is that they require the more or less constant attention of a trained attendant until the eschar is formed; this may take many hours. The other is that in the production of the eschar a certain number of layers of viable epithelium are destroyed; this is amply demonstrated to any one who has tried to remove an eschar from a burned surface only to find a raw bleeding surface or a layer of pus beneath. This is particularly important in the treatment of second degree burns in which the epithelium is not completely destroyed. The rapidity with which epithelization in these second degree burns takes place depends directly on how much viable epithelium remains below the burned surface in the form of unharmed epidermis and hair follicles and the care with which this epithelium is protected.

Petrolatum gauze, either alone or in combination with one of the sulfonamide compounds, comes closer to meeting the requirements of an ideal local application, but this is also time consuming, and if a method of immobilization and sterilization by surgical technic is employed, it becomes even more so. It does not, however, harm surface epithelium, and if gently removed so that there is no tearing of epithelium as evidenced by absence of bleeding, it comes closer to meeting the requirements of ideal local treatment.

In order to make available a standard method of therapy which would allow rapid epithelization of burns by relatively untrained attendants, we have experimented with the method of therapy hereinafter described. In our limited experience, it has proved more suitable to the treatment of second degree burns than any other method that we have used.

Hydrated films were prepared from a hydrophilic cellulose derivative,[2] into which the various chemotherapeutic agents were incorporated. These transparent, thin, light and tough films have the useful property (due to the hydrophilic nature of the plastic employed) of becoming pliable when placed in contact with the moist surface of a burn and of following intimately its delicate contours. Moreover, they adhere closely, remain transparent, permitting observation of the healing process beneath it, and are easily removable by simply sponging with water. If excessive oozing threatens to disintegrate the film, a second or third layer can be applied over the first, thus restoring the strength of the membrane.

2. The cellulose derivative employed at present is methylcellulose. It is likely that other hydrophilic derivatives would be equally satisfactory. These films are not yet on the market.

Also, by mounting these films on gauze, one can give them additional strength, and they can be made into sheets large enough to encircle the torso of an adult.

In medicating these films we have availed ourselves of the latest findings in the field of chemotherapy. Having made observations indicating that azochloramid may inactivate inhibitors of the action of sulfonamide compounds we used this principle to advantage in our work. Also, the recent findings that the effectiveness of sulfanilamide can be stepped up to nearly equal that of sulfathiazole (2-[paraaminobenzenesulfonamido]-thiazole) or sulfadiazine by adjusting the p_H to a slightly alkaline reaction was utilized and thus full advantage taken of the greater solubility of sulfanilamide compared with that of the other sulfonamide compounds. We have clinically experimented with such membranes containing 10 per cent sulfanilamide and buffer, with and without quantities of azochloramid. These films are therefore veritable preformed chemotherapeutic eschars.

Clinically, these membranes have been applied in 10 cases with such exceptional success and have shown such obvious advantages over other methods of therapy for burns that we feel justified in presenting this preliminary report.

These cases represent the last 10 consecutive burns treated in New York Hospital. Five of the patients had severe enough burns to require hospitalization. One of them had several small areas of third degree burns on the dorsum of the ankle, and these areas were not treated with the preformed membrane. In the remaining 5 cases the burned area involved one or more of the extremities, and the patients were treated as ambulatory (table).

The longest elapsed time required for complete healing (such that the patient could actually return to work) was twenty-one days. This occurred in a patient who was burned about the head so extensively that his entire crop of thick hair and his eyebrows were burned down to within a few millimeters of the skin. There were second degree burns of the entire scalp, the face, the ears and the hands. Some difficulty was encountered in applying the membrane to the ears and these areas were slower than the others in healing. This patient required nine days of hospitalization with several plasma transfusions to combat loss of fluids and edema.

The 1 patient with both second and third degree burns required six days to completely epithelize his second degree areas beneath the cellulose membrane and thirty-six days to heal his third degree by second intention.

The 5 patients hospitalized spent an average of seven and six-tenths days in the hospital and required an average of thirteen and two-tenths days for complete epithelization.

Data on Ten Patients with Burns Treated at New York Hospital

Patient	Age, Yr.	Sex	Date	Condition	Treatment
1	..	..	4/27	Second degree burns on volar and dorsal surfaces of forearm three days previously treated with tannic acid and S.A.	Débridement; buffered sulfanilamide powder, petrolatum gauze
			4/30-5/1	Raw weeping surface	Membrane applied
			5/2	Healed completely	Membrane removed
2	3	M	4/29	Third degree burns on left foot and ankle and second degree burns on face, dorsum of left leg and left thigh; 48 hours old; infected	Débridement, third degree areas; buffered sulfanilamide, second degree areas; membrane applied
			4/30	No change; clean under membrane	Membrane applied to face
			5/4	Second degree areas completely epithelized	Membrane removed
3	51	M	5/12	Second degree burns on entire face, scalp, neck, dorsum of right hand and left thumb with marked edema of face and right eye	Débridement; membrane applied
			5/13-5/16	Edema subsided on third day; membrane partially disintegrated	Membrane partially replaced
			5/18-5/20	Low grade fever; most of burn healed; few moist areas	Membrane removed; buffered sulfanilamide applied to few remaining moist areas
			5/30	Healed completely	
4	33	M	5/16	Second degree burns on anterior surface of right leg treated before admission with kaolin cataplasm * and petrolatum	Débridement; membrane applied
			5/21	Completely epithelized	Membrane removed
5	37	M	5/27	Second degree burns on entire right foot and ankle; smaller areas on face and right thigh	Débridement; membrane applied
			5/28	Membrane partially disintegrated	Membrane replaced where necessary
			6/5	Almost completely healed except bony prominences	Membrane removed
			6/8-6/13	Practically healed; discharged	Buffered sulfanilamide to few remaining moist areas
6	..	F	6/10	Second degree burn on right thigh, leg and hand	Débridement; membrane applied
			6/11-6/23	Burns healing under membrane; occasionally small portions disintegrated	Membrane renewed over small areas where necessary
			6/19	Membrane removed everywhere; burn completely healed except in two small spots where débridement was not originally carried out	Buffered sulfanilamide to two small moist areas
			6/24	Healed in 14 days; back at work in 11 days	
7	13	F	6/18	Second degree burn on right hand	Débridement; membrane applied
			6/20-6/22	Hand edematous and oozing; membrane partially disintegrated; leukocytic layer formed	Second membrane superimposed; membrane and leukocytic layer removed; membrane replaced
			6/27	Few small infected areas remained	Membrane removed; sulfadiazine powder
			7/6	Almost healed	

Data on Ten Patients with Burns Treated at New York Hospital—Continued

Patient	Age, Yr.	Sex	Date	Condition	Treatment
8	37	F	6/19	First and second degree burns on right hand and thumb; no blebs	Petrolatum gauze
			6/20	Large blebs on thumb and dorsum of hand	Blebs opened; débridement; membrane applied
			6/27	Healed completely	Membrane removed
9	2	M	6/21	Second degree burns on palms and finger tips of both hands and right forearm	Débridement; membrane applied
			6/22	Oozing but clean	Membrane renewed where necessary
			6/23	Leukocytic layer formed beneath membrane	Membrane and leukocytic layer removed; new membrane applied
			6/27	Both hands infected; membrane disintegrated; arm healed	Sulfadiazine powder to right; membrane to left hand
			7/6	Left hand healed completely; few areas of granulating tissue remained on right hand	Sulfadiazine powder to right hand
10	2	M	6/23	Bilateral second degree burns on the anterior part of the chest	Débridement; membrane applied
			6/24	Clean	Membrane partially renewed
			6/27	Discharged	
			7/1	Practically healed in 7 days	Membrane removed

* The proprietary preparation used was essentially the same as cataplasm of kaolin, N. F.

The 5 ambulatory patients required an average of eleven and six-tenths days for complete epithelization. This represents a total average of twelve and four-tenths days for the 10 cases.

Admittedly, in none of these cases was the condition of the most severe type, nor were any of the patients in shock; only 2 of them required plasma transfusions, but on the whole the average length of hospitalization was much shorter than that of 103 patients hospitalized between 1932 and 1941, for whom the average was twenty-five days.

In treating these burns we have used the following technic: When the burn is first seen in the accident room, it is débrided and cleaned with solution of sodium chloride or boric acid or azochloramid and sodium chloride as thoroughly as possible, sterile gloves and towels being used but no anesthesia. All dead skin is removed at the first treatment. Cultures and smears are then taken. The preformed membrane is then applied directly to the raw oozing surface, the tissues being relied on to furnish sufficient moisture for the membrane to adhere.

A dry sterile dressing is then placed over the membrane and held by plain gauze bandage.

For the first three or four days there is a steady outpouring of serum from the tissues. During this period the membrane may tend to disintegrate, sometimes requiring additional layers over it. Occa-

sionally, it has been necessary to remove the eschar completely, and under it can usually be found a soft friable layer of leukocytes enmeshed in fibrin which readily peels off the burned surface, leaving a clean glistening surface beneath; to this a new membrane can readily be applied.

When this layer of leukocytes is examined microscopically, usually only a few bacteria are present, and these when found are frequently

Fig. 1.—Photomicrograph of a leukocytic membrane beneath a chemotherapeutic film.

intracellular. This outpouring of leukocytes may be enhanced by the chemotactic effect of the cellulose membrane or some of its constituents.

No attempt has been made so far to use sterilized preformed membranes, but this can be done and is contemplated. However, daily smears and frequent cultures were taken. The smears usually fail to show bacteria, although cultures invariably show staphylococcus or nonhemolytic streptococcus before, during and after healing has taken place. Occasionally other organisms also are found.

We have routinely taken smears from the most exposed and dirtiest-looking portions of the burned areas and then counted twenty oil immersion fields and averaged the count. If this was above twenty, it was called infinity. The results were then plotted as shown in the example given in figure 2.

After the cellulose membrane is removed, any small moist areas remaining are powdered with buffered sulfanilamide powder, and a dry dressing is applied directly over them. The dressing is removed in a day or two and the application repeated if necessary. However, in most

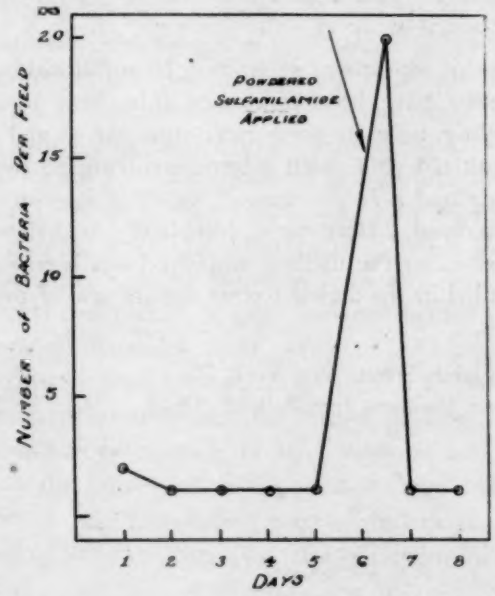

Fig. 2.—Bacterial counts taken on smears from patient 6. The infecting organism was Staphylococcus albus. The high count on the sixth day was obtained from a small infected area.

cases a crust forms under which healing takes place rapidly, and no further dressing is necessary.

We have experimented with several different thicknesses of preformed eschar but find the thinner ones easier to apply and more readily replaceable.

In 3 cases the sulfanilamide concentration in the blood also was determined. The results indicate that only small amounts of the sulfanilamide have been absorbed. Three determinations yielded 0.0, 0.35 and 0.65 mg. per hundred cubic centimeters. In none of the cases was there any manifestation of toxicity due to sulfanilamide.

Apart from the good clinical results obtained in these 10 cases, the obvious advantages of this form of treatment are its ease and rapidity

of application. Given the sudden incidence of a large number of burns (on board a ship for instance), this membrane can be applied quickly and easily and can be held in the proper position by a dry dressing placed over it. The membrane can be applied by any one trained in first aid. It obviates the necessity of applying ointments, salves or jellies. If it is desirable to remove the membrane, it need merely be moistened with sterile water or solution of sodium chloride. Another practical advantage of this medication is that the material used for it is light and not bulky. A few grams of the membrane replaces bulky and heavy containers. This aspect may be of prominent importance when shipping space is scarce.

NOTE.—Since this report was submitted, 10 additional cases of severe second degree burns have been treated in this clinic by this method. The average healing time in these was nine days, and the patients include a 15 month old child with a burn involving 55 per cent of the surface of the body and a Negro man 21 years of age with 35 per cent of the surface involved. Both were completely healed within twelve days. In the later cases the method employed has been essentially the same as that detailed in the article except for the use of pressure dressings in some cases.

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GALLSTONE ILEUS

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A series of 6 cases of gallstone ileus at the Salem Hospital from 1938 to 1940 has focused my attention on this unusual form of intestinal obstruction. In the twenty-five years from 1915 to 1940 this diagnosis has been confirmed in 13 cases at the Salem Hospital. This series is one of the largest to be reported from one hospital. Balch [1] listed only 10 cases from the Massachusetts General Hospital, Boston. Likewise, at the Mayo Clinic, Rochester, Minn., Wakefield, Vickers and Walters [2] found only 10 cases. Yet the incidence of intestinal obstruction in these institutions is of course much greater than in the Salem Hospital.

According to the literature, intestinal obstruction is due to a gallstone in about 1 to 2 per cent of the cases. In this series gallstones were responsible in 6 per cent. In 1925 Moore [3] made an estimate of 400 reported cases of ileus due to a gallstone. Since then hundreds of additional instances have been recorded; hence single case reports now have little value unless some unusual feature is present. In recent years much progress has been made in the diagnosis and the treatment of obstruction of the bowel. The reported average mortality of 50 per cent for gallstone ileus is sufficient warrant for the study of a significant group of cases of this condition, from the standpoint of modern diagnosis and treatment.

AGE

One obvious reason for the high mortality associated with gallstone ileus is the advanced age of the patients. In my series the average age was 66 years. Balch [1] and Borman and Rigler [4] reported an identical average age for their groups of patients. The youngest patient in my series was 50 years old. The oldest, a 79 year old woman operated on by me, recovered from two attacks of gallstone ileus, each necessitating

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1. Balch, F. G., Jr.: Gallstone Ileus, New England J. Med. **218**:457, 1938.

2. Wakefield, E. G.; Vickers, F. M., and Walters, W.: Gallstones Causing Intestinal Obstruction, Surgery **5**:670, 1939.

3. Moore, G. A.: Gallstone Ileus, Boston M. & S. J. **192**:1051, 1925.

4. Borman, C. N., and Rigler, L. G.: Spontaneous Internal Biliary Fistula and Gallstone Obstruction, with Particular Reference to Roentgenologic Diagnosis, Surgery **1**:349, 1937.

jejunotomy, and is therefore the oldest recorded patient to survive recurrent ileus. Several authors, however, have listed recoveries from a single episode in patients over 80 years of age.[5]

SEX

All authors have found a much higher incidence in female patients, out of proportion to the commoner occurrence of gallstones in women. The ratio is about 5 : 1. In the 13 cases at the Salem Hospital there was only 1 man.

MORTALITY RATE

In the present series the mortality rate was 46 per cent, if 1 non-operative patient is included. This patient had definite, incomplete ileus clinically and roentgenologically at the time of entry into the hospital. A gallstone impacted in the rectum was dislodged digitally. Excluding this case, the mortality rate is 50 per cent, which coincides with an average figure obtained from the literature. Grey-Turner had 8 recoveries in 10 operative cases; in contrast, Möller [6] reported an 89 per cent mortality rate.

BILIARY FISTULA

Practically all gallstones which cause ileus are dislodged into the intestines through a cholecystoenteric fistula. The subject of spontaneous internal biliary fistula has recently been reviewed comprehensively by Borman and Rigler. Fistulas of this type are a fairly common complication of long-standing disease of the biliary tract.

In the opinion of most authors an attack of acute cholecystitis subsequent to previous cholelithiasis is often complicated by the intimate adherence of the gallbladder to an adjacent viscus, usually some portion of the gastrointestinal tract. However, many patients give a history of long-standing cholelithiasis only, and in some there is little or no evidence of a previous pathologic condition in the gallbladder. Borman and Rigler expressed the opinion that obstruction of the common duct by a stone in the presence of a patent cystic duct is the initial factor in the formation of a fistula. In 109 cases of biliary fistula described by Bernhard,[7] stones were demonstrated in the common duct of 55 patients. The presence of choledocholithiasis may be demonstrated at operation

5. Turner, G. G.: A Giant Gallstone Impacted in the Colon and Causing Acute Obstruction, Brit. J. Surg. **20**:26, 1932.

6. Dulin, J. W., and Peterson, F. R.: Intestinal Obstruction Due to Gall Stones: Report of Ten Cases, Arch. Surg. **38**:351 (Feb.) 1939. Möller, cited by Moore.[3]

7. Bernhard, F.: Die spontanen inneren Gallenfisteln und ihre operative Behandlung, Deutsche Ztschr. f. Chir. **242**:493, 1934.

or at autopsy. In 4 of 6 fatal cases of gallstone ileus at the Salem Hospital autopsies were performed. In 2 patients the common duct was extremely dilated and contained many stones. In the remaining 2 the duct was definitely dilated and in 1 instance filled with sandy fluid. It seems a reasonable assumption that obstruction of the common duct is a prominent factor in the production of this fistulous drainage of the biliary tree. It follows that the occurrence of cholecystoenteric fistula may be a life-saving accident, as Dean [8] emphasized, since dilated infected biliary radicles can then be drained into the intestine despite the obstruction of the common duct.

In the large group of 176 cases of cholecystoenteric fistula from the Mayo Clinic, in all of which the condition was due to gallstone ulceration (rather than, for instance, to carcinoma), the sites of the fistulas were as follows: cholecystoduodenal in 101 cases; cholecystocolic in 33 cases; cholecystogastric in 7 cases; multiple in 11 cases.

In 24 cases the gallbladder had ruptured and stones had been discharged into the abdominal cavity. The cholecystocolic fistulas have little bearing on the problem of subsequent ileus, because stones ulcerating into the large intestine are usually defecated uneventfully. In addition to being in the intestinal tract, fistulas have been reported as emptying into the bronchial tree, the pleural and pericardial cavities, the pelvis of the kidney, the gravid uterus and ovarian cysts.

It has been argued that fewer cases of cholecystoenteric fistulas and gallstone ileus will occur in communities in which early operation is frequently performed for acute cholecystitis. It is certainly true that such complications can be largely prevented by earlier operation for the predisposing chronic disease of the biliary tract. It is not easy to determine from the history how often acute cholecystitis is a factor. The symptoms suggesting an attack of acute cholecystitis may closely resemble those due to biliary colic. Likewise, the symptoms which may attend the migration of a stone from the gallbladder to the intestine some months or perhaps years prior to the occurrence of ileus are not unlike those associated with an attack of acute cholecystitis. Case 1 illustrates five characteristic stages in a case of gallstone ileus: (1) antecedent acute cholecystitis; (2) chronic cholelithiasis; (3) the passage of a gallstone through the fistula into the intestine; (4) the recurrent bouts of intestinal colic; (5) the final ileus due to the impacted gallstone.

CASE 1.—A. J., a 49 year old woman, had had postprandial epigastric bloating and tenderness in the epigastrium for four years prior to her first entry into the hospital. In October 1937, two and one-half years prior to her gallstone ileus, she had been hospitalized for three weeks at the Salem Hospital because of an attack of acute cholecystitis. At that time she had had nausea, vomiting, fever

8. Dean, G. O.: Internal Biliary Fistulas, Surgery **5**:857, 1939.

and pain in the right upper quadrant of the abdomen. A tender gallbladder was palpated. She had no jaundice. A cholecystogram revealed a nonfunctioning gallbladder. This attack subsided readily, and operation was withheld because of her cardiac condition. She continued to experience epigastric bloating two or three times a week.

Two and one-half months prior to the onset of ileus she experienced a sudden epigastric sensation of "something swelling as though it were going to burst or blow up inside of me." It seems probable that the large gallstone passed into the intestine at that time.

Five weeks before her present entry, her physician thought she had intestinal grip, because of vomiting, diarrhea and periumbilical cramps. This episode lasted

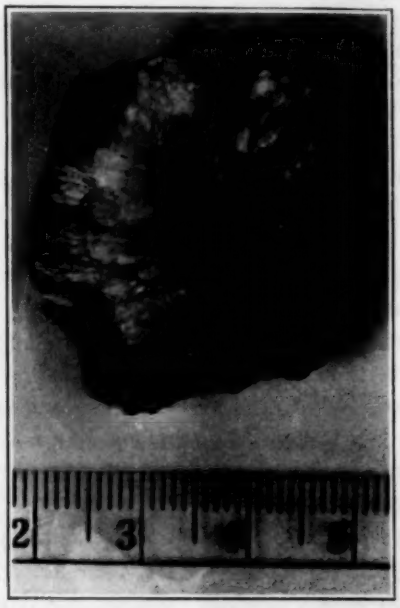

Fig. 1 (case 1).—This huge gallstone impacted in the rectum broke in half during digital removal.

two weeks, and a similar occurrence took place one week prior to entry, with severe midabdominal cramps and vomiting but with no distention.

At her entry, in March 1940, a rectal examination disclosed an impacted gallstone low in the rectum, visualized in the flat plate of the abdomen made on admission to the hospital. The stone broke in half on digital removal (fig. 1).

A cholecystogram showed a nonfunctioning gallbladder. Linear shadows of diminished density in the right upper quadrant of the abdomen suggested gas-filled biliary ducts. An enema of barium sulfate revealed extravasation of the contrast medium from the region of the hepatic flexure into the biliary ducts and thence to the stomach and the duodenum (fig. 2). A diagnosis of cholecystocolic fistula was made. Although operative intervention was not required, the character of the patient's symptoms warranted the diagnosis of actual incomplete ileus. Closure of her fistula was discussed, but in the absence of symptoms of cholangitis the risk was deemed greater than the indication.

In September 1941, eighteen months later, the patient was and had been well except for several chilly sensations. She had had no jaundice, fever or loss of weight, despite her cholecystocolic fistula. She no longer had any indigestion.

Eight of the 13 patients gave an antecedent history suggestive of disease of the biliary tract. Six of them had had an acute episode which may have been acute cholecystitis, but only in case 1 was the evidence sufficient to permit that diagnosis. The remaining 5 people gave no history which implicated the gallbladder. The absence of such

Fig. 2 (case 1).—Cholecystocolic fistula diagnosed roentgenologically with an enema of barium sulfate. The barium sulfate extravasated from the region of the hepatic flexure (through the fistula) into the biliary ducts and thence to the duodenum and the stomach.

a history is not at all uncommon in cases of gallstone ileus, although it seems extraordinary that a fistula could occur without associated symptoms. Case 2 is illustrative:

Case 2.—Mrs. G. W. T. had had a large ovarian cyst removed when she was 68 years old; at this time a stone the size of a walnut was felt within the gallbladder, which was neither thickened nor adherent. Nine years later the patient

had gallstone ileus requiring jejunotomy, from which she recovered uneventfully. In the intervening nine years she had had no acute or chronic symptoms of disease of the gallbladder.

Whether gallstones which may later obstruct the intestine ever pass into the duodenum via a greatly dilated common duct is controversial. It appears that authentic cases of such an occurrence have been recorded. Many surgeons have encountered an enormously dilated common duct, sometimes reported as resembling a section of small intestine. It is established that passage of large stones may render the sphincter of Oddi incompetent, so that a reflux of gas or barium sulfate through the common duct may outline the biliary tree, thus providing a valuable roentgen finding. The average-sized stone which causes ileus would not pass through the common duct, but many factors in addition to the size of the stone contribute to the occurrence of ileus. Several authors report fatal cases of ileus due to relatively small stones.[9] Cases have been described in which the obstructing stone was thought to have reached the small bowel by way of the common duct, because no fistula could be demonstrated between the gallbladder and the bowel. However, such fistulas may close off completely after the passage of the stone, so that at a later date only dense adhesions mark its site. In 7 of 36 cases of gallstone ileus reported by Courvoisier,[10] in which autopsy was done, no fistulous tract could be found.

FISTULA AT AND AFTER THE PASSAGE OF THE STONES

It is not surprising that gallstones lodged in an inflamed gallbladder tend to be extruded through a fistula when one has formed. Progressive shrinking of the entire gallbladder slowly forces its contents into the lumen of the bowel, where free drainage exists. The transit of the stone is occasionally signalized by symptoms resembling those of a stone of the common duct or of acute cholecystitis. Rarely, duodenal obstruction ensues because of a large stone lodged partly in the gallbladder and partly in the duodenum, as in the 10 cases tabulated by Thompson.[11] At times, jaundice and biliary colic attend the passage of the stone due to the proximity of the inflammatory mass to the common duct. The presence of a fistula does not insure the emptying of the gallbladder, as stones are often found in the gallbladder even after one or more have been passed. In Bernhardt's series of 109 fistulas, stones were still present in the gallbladder in all but 17 cases.

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9. Wangensteen, O. H.: The Therapeutic Problem in Bowel Obstruction: A Physiological and Clinical Consideration, Springfield, Ill., Charles C. Thomas, Publisher, 1937. Borman and Rigler.[4]

10. Courvoisier, L. G.: Casuistisch-statistische Beiträge zur Pathologie und Chirurgie der Gallenwege, Leipzig, F. C. W. Vogel, 1890, vol. 12.

11. Thompson, cited by Henry, M. J.: Gallstones Causing Intestinal Obstruction, Tr. South. S. A. **44**:421, 1931.

When fistulous communication exists between the gallbladder and the upper part of the intestinal tract, further symptoms referable to the fistula may cease once the stones have been discharged or symptoms of chronic cholecystitis may persist. If the gallbladder has drained into the colon, symptoms of cholangitis, namely, chills, fever and loss of weight, are often encountered. In their series of 32 patients with cholecystocolic fistulas, Wakefield, Vickers and Walters found that 19 had recently lost 15 to 40 pounds (6.8 to 18.1 Kg.). These authors commented that it is desirable to operate and close such fistulas because of the frequency of cholangitis and hepatitis. However, a number of authors have

Fig. 3.—This small, shrunken gallbladder emptied directly into the duodenum. The hole in the gallbladder measured 1.9 cm., whereas the gallstone measured 6.5 by 4 cm.

reported cases of cholecystocolic fistula without evidence of ascending infection. In the present series 2 patients had multiple fistulas to the duodenum and the colon for over one year with no symptoms of cholangitis.

Most authors have advised against surgical attack on the fistulous tract after the patient has recovered from gallstone ileus, because of the great difficulty in closing off the opening into the intestine. A great many fistulas close spontaneously. Whether or not this occurs in a particular case is probably related to a patency of the cystic duct. It is often possible to outline the biliary tree because gas or barium sulfate flows through the fistula into the gallbladder and thence to the common duct. If the cystic duct ceases to be patent, the free biliary flush through

the gallbladder ceases. The mucosa of the gallbladder has often been destroyed by the chronic inflammation and ulceration due to the stone. Under such circumstances the gallbladder becomes the blind end of a sinus which tends to close, so that at later operation or necropsy only a dense mass of adhesions may be found. In 3 of the cases in which autopsy was performed such a process was in evidence. In 2 instances the fistulous opening into the duodenum measured 1.5 and 1.0 cm. respectively, whereas stones of a much larger diameter had been removed from the small intestine at operation a few days earlier. In a third case the opening into the duodenum was 1.9 cm. in diameter, whereas the extruded gallstone measured 6.5 by 4 cm. Figure 3 shows the autopsy specimen with the stone held above the fistula.

MECHANISM OF BOWEL OBSTRUCTION

Owing to the progress in diagnostic roentgenology, there has been a reversal of opinion with regard to the proportion of cholecystoenteric fistulas to gallstone ileus. In 1890 Courvoisier found three times as many cases of ileus on record as cases of fistula. In 1939 Wakefield, Vickers and Walters studied 176 cases of fistula, among which there were only 10 cases of ileus. It is evident that the majority of gallstones ulcerating into the lumen of the bowel are passed in the stools. Moreover, the presence of biliary fistula must be fairly common and readily discovered if looked for by roentgen examination.

It needs to be emphasized that gallstone ileus is an obturation form of intestinal obstruction (i. e. caused by a loose foreign body within the lumen of the bowel). The gallstone usually commences its downward progress in the duodenum, which is the widest portion of the small intestine. Almost all stones ejected into the colon make their way through the anus without difficulty because of the large diameter of the colon. In the majority of cases the ileum is the site of arrest in the small bowel inasmuch as there is progressive narrowing of the intestinal lumen as the ileocecal valve is approached. Barnard [12] has stated that stones less than 2.5 cm. in diameter are passed spontaneously. However, many factors in addition to the size of the stone influence the occurrence of obstruction. The sharp edges of the stone, kinks in the bowel because of adhesions, the presence of Meckel's diverticulum, a slow rate of peristalsis and ulceration of the wall of the bowel from the trauma of the stones are factors which may precipitate obstruction in cases in which the gallstone is relatively small. In my case of recurrent gallstone ileus, the second episode was caused by a stone smaller than a previously defecated stone.

12. Barnard, H. D.: Intestinal Obstruction Due to Gallstones: Report of Three Cases with Summary of Five More Cases from the Records of the London Hospital, 1893-1901, Ann. Surg. **36**:161, 1902.

Most writers have expressed the opinion that a stone can enlarge during its stay in the bowel. Wangensteen said that this is especially true if a stone remains in one portion of the bowel for some time during which a medicament, such as bismuth subnitrate, calcium or magnesium carbonate, is taken orally. A number of cases have been cited in which the available evidence suggests that the gallstones had been present within the bowel for years. In a recent case of Clute's, it seems certain

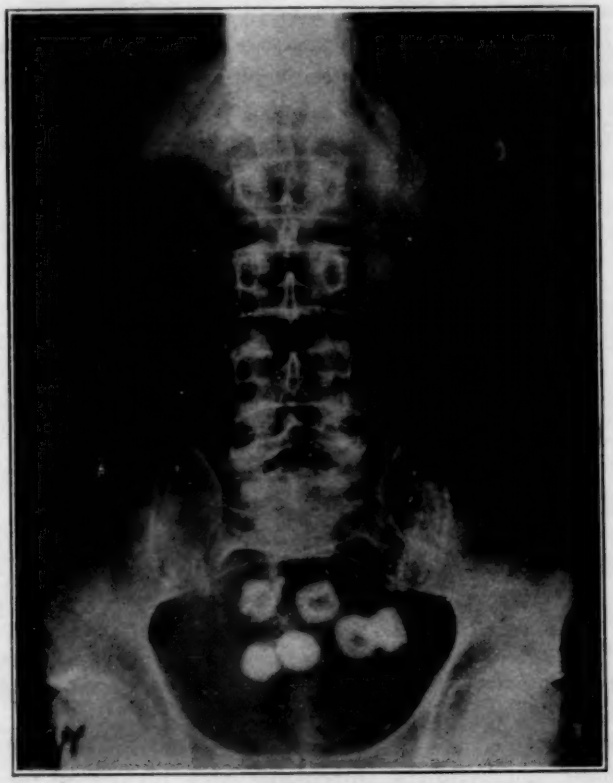

Fig. 4 (case 3).—This patient had multiple gallstones in the ileum for over five years with persistent incomplete intestinal obstruction. Spontaneous closure of the cholecystoduodenal fistula took place.

that the gallstones were present within the small intestine for about five years (fig. 4):

CASE 3.—H. H., patient of Dr. Howard M. Clute, had had marked loss of weight, nausea and vomiting and had been unable to take solid food for five years. At cholecystectomy only dense adhesions to the duodenum marked the site of the fistula. Subsequently two resections of small intestine were required to remove over a dozen gallstones which were fixed in place in the ileum by multiple areas of constriction of the bowel.

The final arrest of the stone may occur at any level in the intestinal canal. In 6 patients in this study the jejunum was the site of the obstruction, although the terminal part of the ileum is a commoner location. Frequently a temporary halt occurs and is perhaps accompanied by mild obstructive symptoms. Because of ball valve action plus the increased peristaltic effort the standstill may be overcome; symptoms may subside, and downward progress may be resumed. When the stone is finally halted, the block is usually mechanical in nature, and therefore circulation in the bowel is rarely jeopardized until late. The obstruction is not usually a complete one; hence marked distention is not characteristic. Occasionally a sharp stone ulcerates through the intestinal wall; in this event the development of obstruction is related to the associated

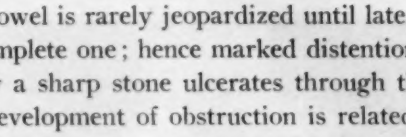

Fig. 5.—Three gallstones from the same patient. The upper two caused separate attacks of intestinal obstruction. The bottom one was defecated.

peritonitis. Wangensteen visualized the occurrence of volvulus of the loop of bowel containing the obstructing stone because of the distention and the weight of the proximal loop. Rarely, the obstructive syndrome results from an intussusception with a large fixed gallstone as the leading point.

SIZE OF THE STONE

Wangensteen stated that stones large enough to occlude the intestinal lumen are usually at least the size of a walnut. In my series the weights and dimensions of only 5 stones were known. Their average weight was 19.5 Gm. The largest recorded stone was removed successfully from the transverse colon of an 81 year old man by Turner. It weighed 5 ounces (155.5 Gm.) and measured 7 by 6 by 17 cm. Wangensteen pointed out the role of spastic obstruction by calling attention to a stone so small that it weighed less than 4 Gm. yet caused fatal ileus. In my

case of recurrent ileus a defecated stone weighed 13.2 Gm., whereas the stones causing the two bouts of intestinal obstruction weighed respectively 12.7 and 19.0 Gm. (fig. 5).

SYMPTOMS

In a review of a great many case histories the delay between onset of symptoms and surgical intervention is striking. It is tragic that a form of obstruction of the bowel so readily relieved should be manifested by such indefinite, misleading symptoms with the frequent result of delayed operation. The usual preoperative diagnosis is simply intestinal obstruction on the basis of a history of pain, vomiting and obstipation. However, because of the mechanism of the obstruction, such a history is neither constant nor clear. Symptoms may be correlated with pathologic sequences, viz.: (1) symptoms referable to disease of the gallbladder, usually of long duration; (2) symptoms referable to the emigration of the stone into the intestine from the gallbladder; (3) symptoms pertaining to the current obstruction.

From the majority of patients a history of previous complaints concerning the biliary tract is elicited. Eight of the patients in my series gave such a history, whereas 5 women did not. Sometimes this history is obtainable only after the operation for gallstone ileus, as Colcock mentioned.[13]

When a large gallstone passes into the intestine from the biliary tract, the event may be signalized by a definite bout of severe pain in the upper part of the abdomen and vomiting. However, cholecystitis or biliary colic may also produce similar symptoms. In 2 of our cases it seemed possible from the history to fix the date of transit of the stone. In 1 case this took place four months prior to ileus. In the second case, it occurred one year before and was marked by severe colic and jaundice which quickly subsided.

As the stone makes its downward progress, it characteristically causes cramps. At times temporary ileus with nausea and vomiting occurs. Such episodes may resemble so-called intestinal grip, and this diagnosis had been made in several of our patients prior to the final arrest of the stone. Thus dangerous delay may occur. According to Mast [14] and others such recurrent bouts of temporary obstruction of the small bowel may take place for a year or more prior to the end stage of persisting obstruction. In Clute's case, symptoms of partial obstruction were present for five years.

Rarely, the clinical picture of simple mechanical obstruction may be confused by the complicating peritonitis from perforation. Even

13. Colcock, B. P.: Intestinal Obstruction Due to Gallstones, Lahey Clin. Bull. **2**:47, 1940.

14. Mast, W. H.: Recurrent Intestinal Obstruction Due to Gallstone, Am. J. Surg. **32**:516, 1936.

when the stone has come to a final halt, the resultant symptoms are not clearcut as in other forms of obstruction. Colic, nausea and vomiting may be intermittent because of incomplete obstruction. Distention is often not pronounced. Tenderness is not a common finding, since obstruction is purely mechanical at the onset.

Thus the equivocal character of the premonitory symptoms and the actual ileus contribute to the high mortality rate associated with this condition. Many of the patients in my series were not hospitalized until obstruction had been present for several days. The average duration of symptoms prior to hospitalization was two and a half days in those patients who survived and six and three-quarters days in those who died.

DIAGNOSIS

The correct diagnosis of gallstone ileus is rarely made prior to operation or autopsy. Lowman and Wissing [15] stated that preoperative roentgen diagnosis of an intestinal obstruction due to a gallstone has been recorded only 11 times. However, the correct diagnosis has been made in addition in some cases in which operation was not performed and in which autopsy later confirmed the roentgen finding. In 1 of my cases (fig. 6), such a diagnosis was advanced by the roentgenologist on the basis of having demonstrated a cholecystoduodenal fistula plus the presence of gas-filled loops of small bowel. The diagnosis by roentgen examination of cholecystoenteric fistula is not uncommon. In this series of 13 cases a correct clinical diagnosis of gallstone ileus was made in 3 instances prior to operation. For 1 woman the diagnosis was obvious, since she had recently passed two gallstones per anum.

In an elderly patient, usually a woman, with a history of disease of the gallbladder, often with repeated episodes, the occurrence of a nonfulminating recurrent obstructive syndrome, with perhaps a shifting focus of symptoms, suggests ileus caused by a gallstone. Such a cause is more to be thought of in those cases in which other commoner forms of obstruction, such as tumor or adhesions, are not suggested. In the history the two commonest features are: (1) the history of chronic disease of the gallbladder, which is obtained in about 50 per cent of the cases and (2) the recurrent character of the obstructive symptoms, which is also true in about 50 per cent of the cases.

Physical findings may be inconclusive. Distention may be only moderate as some gas passes by the obstructing stone. Tenderness is usually a late sign, signifying "weeping" of the dilated obstructed bowel, the development of peritonitis from perforation proximal to the obstruction or a decubitus ulceration through the wall of the bowel at the site of the stone. Irreversible circulatory changes in the wall of the bowel

15. Lowman, R. M., and Wissing, E. G.: Preoperative Roentgen Diagnosis of Gallstone Ileus, J. A. M. A. **112**:2247 (June 3) 1939.

rarely characterize an obturation type of intestinal obstruction until late. A mass is so rarely felt that this sign has little diagnostic value. Powers [16] mentioned that tenderness beneath the right costal margin was suggestive when present.

It is important to distinguish the intestinal colic due to the passage of an irritating foreign body from the colic set up by obstruction of the lumen of the bowel. In a review of a great many case histories, a number of patients were listed who suffered mild colic relieved by the

Fig. 6.—The diagnosis of cholecystoduodenal fistula was made on the presence of this small mushroom-like cavity projecting up from the duodenal cap. Fourteen days later the large gallstone seen in figure 3 was found in the ileum at autopsy.

defecation of a gallstone. Wagner [17] listed 334 cases of gallstone ileus, but 93 of the patients defecated the gallstone. A report from the Mayo Clinic described 176 cholecystoenteric fistulas but enumerated only 10 cases of gallstone ileus. Therefore, we may conclude that gallstones are

16. Powers, J. M.: Acute Intestinal Obstruction Due to Impacted Gallstones: Report of Four Cases, Surg., Gynec. & Obst. **28**:416, 1928.

17. Wagner, A.: Ileus durch Gallensteine, Deutsche Ztschr. f. Chir. **130**:353, 1914.

often extruded into the intestine and passed spontaneously per anum. When no other symptom but colic is present, it is clear that a diagnosis of intestinal obstruction cannot be made.

The roentgenologist is the chief source of diagnostic aid. His evidence is derived from his observations of (1) the fistula, (2) the gallstone within the bowel and (3) the obstructed bowel independent of whether or not a gallstone can be visualized.

A scout film of the abdomen may confirm the clinical impression of an obstructed bowel and even suggest the location of the obstruction. As the stone moves along there may be a progressive shift in the localization of the gas within the bowel as revealed by roentgenograms. The majority of these gallstones are not visible in the roentgenograms, but occasionally the obstructing stone can be seen. Distended loops of bowel may obscure the stone. In 3 of my patients an opaque object was seen within the bowel but not identified as a stone. In 3 others a definite diagnosis of an obstructing gallstone was made by roentgen examination, helped in 1 case by the history of recent defecation of a gallstone. When a Miller-Abbott tube has been successfully passed into the small intestine, the introduction of a small amount of thin barium sulfate after the downward progress of the tube has been halted may delineate the impacted stone. In the majority of cases in which correct preoperative roentgen diagnosis of gallstone ileus has been made, the oral administration of barium sulfate has demonstrated the obstructing stone as a filling defect occluding the intestinal lumen. Such a practice is of course dangerous but is periodically resorted to in cases of gallstone ileus, because of the obscure course of the obstruction.

The diagnosis by roentgen examination of cholecystoenteric fistula is additional evidence pointing to the possibility of gallstone ileus, although such a fistula may be long standing and unrelated to the present obstruction. Borman and Rigler made a comprehensive study of fistulas of this type. They advised spot films over the region of the gallbladder in addition to the routine scout film of the abdomen. The biliary radicals may be outlined by the presence of gas within the ducts. This was the case in 2 patients in my group. However, a similar roentgen appearance can result from incompetency of the sphincter of the common duct due to the passage of a large gallstone or from duodenal ulceration in the vicinity of the lower end of the common duct. Roentgen examination may show absence of gallstones from a gallbladder in which their previous presence had been demonstrated. Cholecystograms show no filling of the gallbladder when such a fistula exists.

When barium sulfate is given by mouth in the presence of a cholecystoduodenal fistula, the fistula and biliary tree are usually outlined by the regurgitation of barium sulfate from the intestinal tract. Borman and Rigler emphasized characteristic changes in the mucous membrane

adjacent to the intestinal stoma of the fistula. These consist of irregular folds of mucous membrane with loss of elasticity. There may even be stenosis of the bowel at this point. Multiple fistulas to the bowel and nearby organs are not rare. At times an enema of barium sulfate reveals a cholecystocolic fistula, and there have been 2 cases at the Salem Hospital in which the stomach has been filled with barium sulfate given by rectum. The patient in case 1 was given an enema of barium sulfate on March 21, 1940. After the barium sulfate reached the hepatic flexure, it extravasated into the biliary ducts, the duodenum and the stomach. The sinus tract to the upper part of the gastrointestinal tract was in the region of the first and second portions of the duodenum (fig. 2).

TREATMENT

Hardly any type of intestinal obstruction challenges the surgeon's judgment more than gallstone ileus. In one sense newer methods of treatment complicate rather than simplify the therapeutic problem. Prior to the development of nonsurgical decompression, the clinical condition of the patient with intestinal obstruction was manifested by his symptoms of persistent pain, nausea and vomiting and by distention. These signs and symptoms are abolished by adequate suction decompression through an inlying tube. Gallstone ileus represents a simple mechanical obstruction without the threat to the blood supply of the bowel until late. Tenderness is not characteristic of the clinical picture. However, if operation is delayed too long, two catastrophes may ensue with little or no warning so long as medical decompression is carried out. The incarcerated stone may ulcerate through the wall of the bowel, or perforation of the bowel proximal to the stone may occur. The difficulty of complete evacuation of the small intestine may permit distention in several feet of bowel proximal to the site of the stone, and this amount of distention may escape both clinical and roentgenologic detection. The site of obstruction is usually low in the small bowel. In the last case of gallstone ileus at the Salem Hospital the fact of a persistent obstruction in the small intestine was not recognized until late, owing partly to the elimination of the evidence for obstruction by suction decompression. Multiple perforations occurred in the small intestine proximal to the stone even though clinical signs of obstruction were inconclusive in the presence of suction decompression.

In a recent study of 136 cases of acute mechanical obstruction of the small bowel at the Massachusetts General Hospital, McKittrick and Sarris [18] made the striking observation that not a single death occurred in a group of 43 patients operated on within twenty-four hours of the

18. McKittrick, J. B., and Sarris, S. P.: Acute Mechanical Obstruction of Small Bowel: Its Diagnosis and Treatment, New England J. Med. **222**:611, 1940.

onset of their obstruction. Operation should be performed in a case of gallstone ileus as soon as it is apparent that the progress of the stone has stopped and that more or less complete obstruction of the bowels exists.

When a patient is suffering cramps, perhaps in varying locations of the abdomen unaccompanied by vomiting and distention, observation may be carried out for a period during which rest in bed, use of antispasmodics and a liquid diet can be instituted while the abdomen is studied by repeated clinical and roentgen examinations. In my series such a situation due to a gallstone which later was passed per anum existed in 2 persons. Intestinal intubation may be desirable as an aid in the localization of the gallstone within the intestine by the use of thin barium sulfate introduced through a tube. Its employment in a case of actual obstruction in place of immediate operation and with the object of relieving a spastic obstruction is a dangerous practice in my opinion, although Wangensteen mentioned 2 patients with small stones and some degree of spastic obstruction who were treated with inlying suction decompression and then passed the gallstones in the stools. As an adjunct to immediate operation it is of course useful. When such decompression is practiced on a patient whose condition does not permit immediate operation, a surgical procedure should nevertheless be carried out at the earliest possible moment if the obstruction is persistent as demonstrated by clamping the tube or if in the meantime studies have revealed a stone within the lumen of the bowel.

Enterotomy is the operation of choice. Enterostomy is usually unnecessary, as adequate decompression of the bowel above the stone can be secured by the Miller-Abbott tube, which should be passed into the duodenum preoperatively. When possible, the obstructing stone should be milked upward a short distance so that the opening in the bowel is not made at the point of incarceration, where wound healing may be poor. The longitudinal incision should be closed transversely by an inverting type of suture and reenforced by a continuous Cushing stitch followed by a row of interrupted mattress sutures. It is unwise to attempt to crush the stone within the lumen of the bowel, because such an effort may result in dangerous trauma to the wall of the intestine. Adhesions and kinking of the bowel may be minimized by tacking a free omental graft over the suture line with a few interrupted sutures. The protection of the margins of the wound from contamination at the time of enterotomy is particularly important. The contents of the blocked intestine are extremely infectious, owing partly to the draining biliary fistula. It is desirable to employ some impermeable pad against the wound, such as the cellophane-lined pad

advocated by Lahey.[19] In this series wound sepsis occurred in 6 instances. In 2 women who recovered there was sloughing of the fascia. Three of the 6 patients died, and in 2 of them the extent of the wound sepsis appeared to play a significant role in causing their death.

The possibility of multiple gallstones must be kept in mind at operation. In 3 of Holz's [20] series of 5 cases of repeated operation for gallstone ileus, the second stone had to be removed during the immediate convalescence from the first operation. It is probable that the second stone was already in the intestine at the time of the first operation. Numerous authors have reported the presence of multiple stones in the intestine at operation, often close together but sometimes separated by considerable distance. The presence of facets on the obstructing stone indicates the need for additional search provided the patient's condition permits. The proximal parts of both the intestine and the biliary tract should be palpated. Detection of stones within the gallbladder may be difficult owing to dense adhesions. Additional stones can often be removed from the intestine through a single incision. However, it will rarely be feasible to perform any operation on the gallbladder after removing the stone from the bowel.

Reports of 9 cases of recurrent gallstone ileus have been published. One of the patients was operated on by me and was the oldest patient on record to recover from two bouts of obstruction both necessitating enterotomy.[21]

CASE 5.—E. D., a 79 year old woman, had known for seven years that she had what was thought to be a single gallstone within the gallbladder. She never had any biliary symptoms except mild indigestion. In March 1939 she had intestinal colic followed by the defecation of two gallstones. Shortly thereafter she had intestinal obstruction and an impacted gallstone was removed from the jejunum. The weight and the diameter of this stone were less than the weight and the diameter of one of the stones defecated a few weeks earlier, with which she had had colic only. Three months later a second jejunotomy was performed to remove another impacted stone (fig. 5).

The distinction between colic and ileus is nicely illustrated by the case just reported. Moreover the removal of one faceted stone makes it necessary to search for additional stones in the intestine or the gallbladder.

The management of the biliary fistula should be regarded as a separate problem. If studies demonstrate a fistula from the gallbladder

19. Lahey, F. H.: A Waterproof Laparotomy Pad of Gauze and Cellophane, J. A. M. A. **104**:1990 (June 1) 1935.

20. Holz, E.: Zur Frage des Gallensteinileus, Arch. f. klin. Chir. **155**:166, 1929.

21. Hinchey, P. R.: Recurrent Gallstone Ileus, New England J. Med. **223**:174, 1940.

to the stomach, the duodenum or the upper part of the jejunum, it seems justifiable to do nothing about the fistula unless symptoms of cholangitis develop. McQueeney [22] cited 2 instances of cholecystoduodenal biliary fistula of nineteen and fifteen years' duration respectively, without evidence of cholangitis. The majority of the patients are old, and closure of the fistulous communication with the bowel is considerably hazardous. Most authors are opposed to immediate attack on the biliary fistula. There have been cases in which cholecystectomy has been performed after a previous fistula from the gallbladder had closed spontaneously. In such cases dense adhesions are encountered.

However, if the gallbladder has drained into the colon, cholangitis is a common sequel and is characterized by chills, fever and loss of weight. Wakefield, Vickers and Walters expressed the opinion that it is unsafe to await the development of clinical cholangitis and hepatitis with any cholecystoenteric fistula. There were 32 cholecystocolic biliary fistulas in their series, and 19 of the patients had recently lost 15 to 40 pounds (6.8 to 18.1 Kg.). They recommended early operation on the fistulous tract irrespective of whether it drained into the small or the large intestine. Closure of a cholecystocolic fistula seems desirable if the patient's condition will permit.

SUMMARY

Thirteen cases of gallstone ileus are reviewed.

Gallstone ileus is a complication of chronic disease of the biliary tract. Its occurrence will be lessened by earlier operation on the biliary tract.

Salient points in diagnosis and treatment are discussed.

Dr. Howard M. Clute and the members of the Salem Hospital surgical staff gave permission to use their cases.

355 Essex Street.

22. McQueeney, A. M.: Internal Biliary Fistulae and Intestinal Obstructions Due to Gallstones, Ann. Surg. **110**:50, 1939.

PULMONARY EMBOLISM

CLINICAL AND EXPERIMENTAL STUDY

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Any discussion of pulmonary embolism must concern itself primarily with a consideration of the fundamental problem of venous thrombosis. Many years ago Virchow,[1] Aschoff[2] and Welch[3] set forth the fundamentals of the mechanics of red and white thrombus formation, which can still be found in any modern textbook. Innumerable publications on pulmonary embolism and thrombophlebitis have since confirmed the findings of the original investigators.

The word thrombophlebitis poorly describes the spontaneous venous thrombosis which occurs postoperatively and in medical patients at rest in bed, because the ending of the word suggests that inflammation is present. Any inflammation in the wall of the vein or in the thrombus is a secondary manifestation and not a primary cause. The type of thrombophlebitis caused by local trauma or infection does not pertain to this discussion. Our concern is with spontaneous intravenous clotting, and this will be referred to in the paper by the more descriptive term phlebothrombosis, which was popularized by Ochsner.[4]

The caustive factors in the production of phlebothrombosis are presumably many, and the importance of each has been reviewed.[5] It is rather generally accepted, however, that retardation of venous blood flow is the primary cause. If slowing of the venous circulation is responsible for thrombus formation, it should be possible to produce it

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Read before the Section on Surgery, General and Abdominal, at the Ninety-Third Annual Session of the American Medical Association, Atlantic City, N. J., June 11, 1942.

1. Virchow, R.: Neuer Fall von tödlicher Embolie der Lungenarterien, Arch. f. path. Anat. **10**:225-228, 1856.
2. Aschoff, L.: Thrombosis, Arch. Int. Med. **12**:503-525 (Nov.) 1913.
3. Welch, W. H.: Thrombosis and Embolism, in Allbutt, T. C.: System of Medicine, New York, Macmillan & Co., 1898, vol. 6, pp. 155-285.
4. Ochsner, A., and De Bakey, M.: Thrombophlebitis and Phlebothrombosis: C. Jeff Miller Lecture, South. Surgeon **8**:269-290, 1939.
5. Potts, W. J.: Pulmonary Embolism, Ann. Surg. **111**:554-563, 1940.

experimentally without injury to the intima of the vein, without the use of foreign bodies in the lumen of the vein and without the application of a caustic about the vein.

EXPERIMENTAL OBSERVATIONS

In the first series of 14 experiments on dogs under anesthesia induced with soluble pentobarbital U. S. P. (pentobarbital sodium), a silk ligature was placed around the midportion of the external jugular vein or the femoral vein just below Poupart's ligament and drawn tight

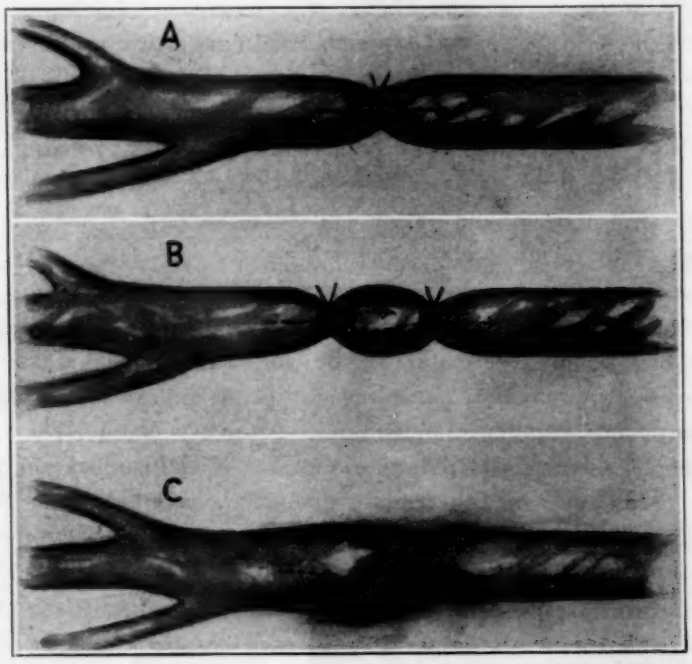

Fig. 1.—Forms of ligation used in the experimental production of thrombus formation. *A*, a silk ligature was placed around the midportion of the external jugular vein or the femoral vein just below Poupart's ligament and drawn tight enough to throttle the blood flow to one half or two thirds of normal. *B*, the external jugular and femoral veins were doubly partially throttled with silk ligatures placed 1 or 2 cm. apart. *C*, the external jugular and femoral veins were completely ligated with a single silk ligature.

enough to throttle the blood flow to one half or two thirds of normal. All animals were killed at the end of seven days. In no instance was there the slightest gross evidence of thrombus formation (fig. 1 *A* and table 1). The negative results suggested that the whirls and eddies of blood described by Aschoff as necessary for thrombus formation

had not been produced. In the Mississippi River in Minnesota, where the stream is wide and shallow and the current is slow and tortuous, there are innumerable islands and shoals. Farther downstream, where the river is deep and the current swift, sediment does not have a chance to accumulate and build up "thrombi."

In a second series of experiments the external jugular and the femoral vein were doubly partially throttled with silk ligatures placed 1 to 2 cm. apart (fig. 1 *B*). It was demonstrated at the close of the operation that blood would flow through the constricted portion of the vein. The only injury to the vein was that incidental to its exposure. All the animals were killed at the end of one week. All specimens were removed while the dog was alive but under anesthesia to avoid mistaking on gross examination a postmortem for an antemortem thrombus. The results are summarized in table 1.

With the exception of one thrombus the size of a grain of wheat, there were no thrombi in 14 external jugular veins one week after

TABLE 1.—*Data on the Experimental Study of Pulmonary Embolism*

Ligation	External Jugular Vein	Thrombosis	Femoral Vein	Thrombosis
Single partial	7	0	7	0
Double partial	14	1*	22	13
Single complete	7	1	12	3†

* Thrombus was the size of a grain of wheat.
† One of these was a tiny thrombus.

double partial ligation. In the femoral veins, on the contrary, thrombi formed between the ligatures or caudal to the distal ligature or both in 13 to 22 veins one week after double partial ligation. In no instance was a thrombus found cephalad to the proximal ligature.

Why thrombosis should occur in the femoral vein and not in the external jugular vein when the procedure was exactly the same in each is a matter of conjecture. That there are valves in the femoral vein and not in the external jugular vein may be of importance. Of more significance probably is the fact that in the dependent legs the return flow of venous blood is retarded. The animal confined in a small cage has little opportunity to exercise but can move the head freely. Guesswork is not in order. The fact remains and is significant that thrombi were formed in several of the femoral veins subjected to double partial ligation but not in the external jugular veins similarly treated.

Grossly these thrombi were dark red masses with grayish white streaks and patches in and about them (fig. 2). The thrombi measured 1 to 5 cm. in length, the average being about 2 cm. In most but not all

instances the clot completely filled the lumen of the vein but was so loosely attached to the intima that unless great care was exercised during removal of the vein the clot fell out. At postmortem examination no emboli were found in the lungs. There was no instance of swelling of the hindleg in those animals in which the femoral vein was completely occluded by thrombus.

Microscopic Examination (Dr. Carl W. Apfelbach).—In the sections (labeled dog 41) of the femoral veins and contained thrombi stained with hematoxylin and eosin and with phosphotungstic acid and hematoxylin there were mixed thrombi. One half of each thrombus was partially canalized and contained remnants of platelet masses. In the other half was a red clot in which there were beginnings of organization. In sections taken at another site, approximately half of the thrombus was white and the other half red. It did not completely occlude the lumen

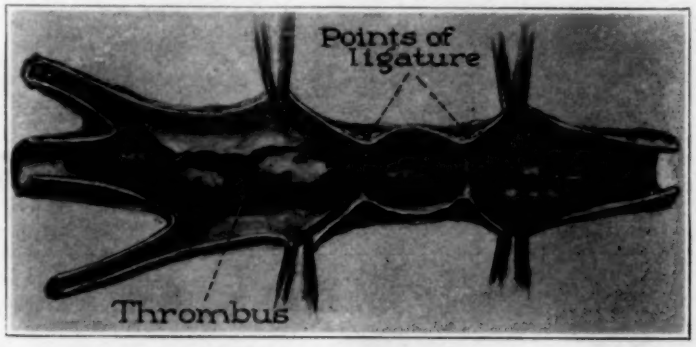

Fig. 2.—A thrombus which formed in a femoral vein one week after double partial ligation.

of the vein. In similarly stained sections (labeled dog 42) the vein was occluded by a thrombus in the center of which were masses of agglutinated platelets and a few polymorphonuclear cells. Sections of the same vein taken at a different level showed organization in the periphery, but the main portion of the clot consisted of unidentifiable granular material. Near the periphery there were masses of agglutinated platelets. In still another section the thrombus was laminated—there were layers of agglutinated platelets separated by layers of red thrombus (figs. 3 and 4).

A third series of experiments was done in which the external jugular and the femoral vein were completely ligated with a single silk ligature (fig. 1 *C*). The object of this simple procedure was to determine whether thrombosis would occur under such circumstances and to compare the character of the clot with that formed in a moving blood stream.

In 7 completely ligated external jugular veins there was 1 thrombus 2 cm. long distal to the ligature. In 12 completely ligated femoral veins 2 moderate-sized thrombi and 1 tiny thrombus appeared distal to the ligature. These thrombi were typical stagnation clots confirmed by microscopic examination (fig. 5).

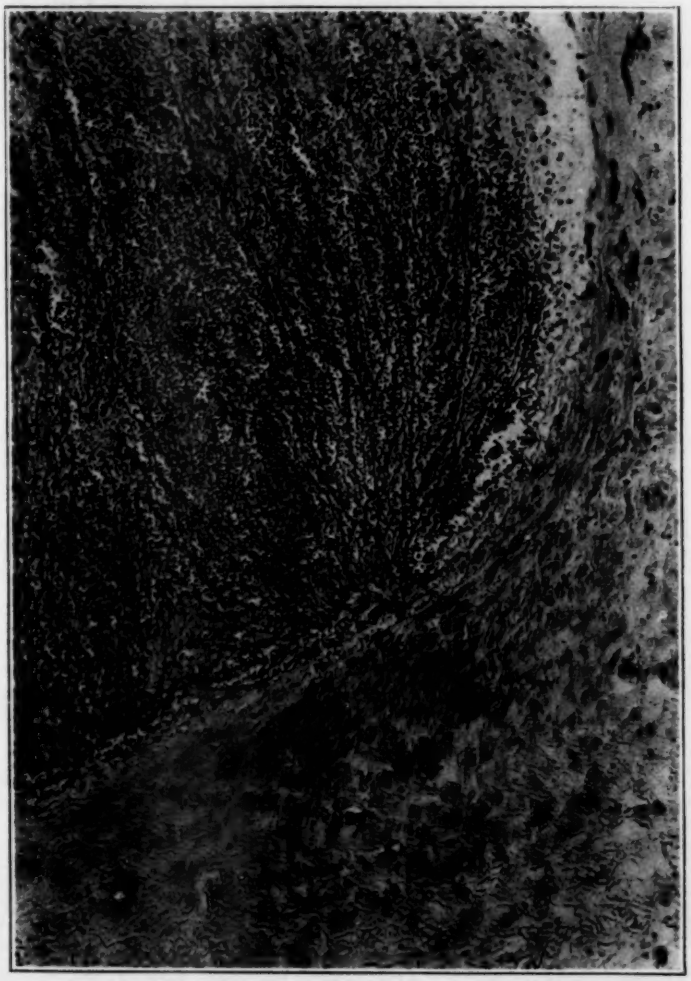

Fig. 3.—Photomicrograph of a section of a thrombus formed in a femoral vein by double partial ligation.

CLINICAL CONSIDERATIONS

Inactivity, we believe, is one of the important causes contributing to retarded circulation and consequent thrombosis. When the muscles of the legs and the abdomen are inactive, there is retardation of blood

flow in the pelvic and femoral veins and their tributaries. Smith, Allen and Craig [6] showed that exercises of the legs decrease the circulation time from the foot to the carotid sinus; that elevation of an extremity decreases the circulation time in that extremity; that warmth of the

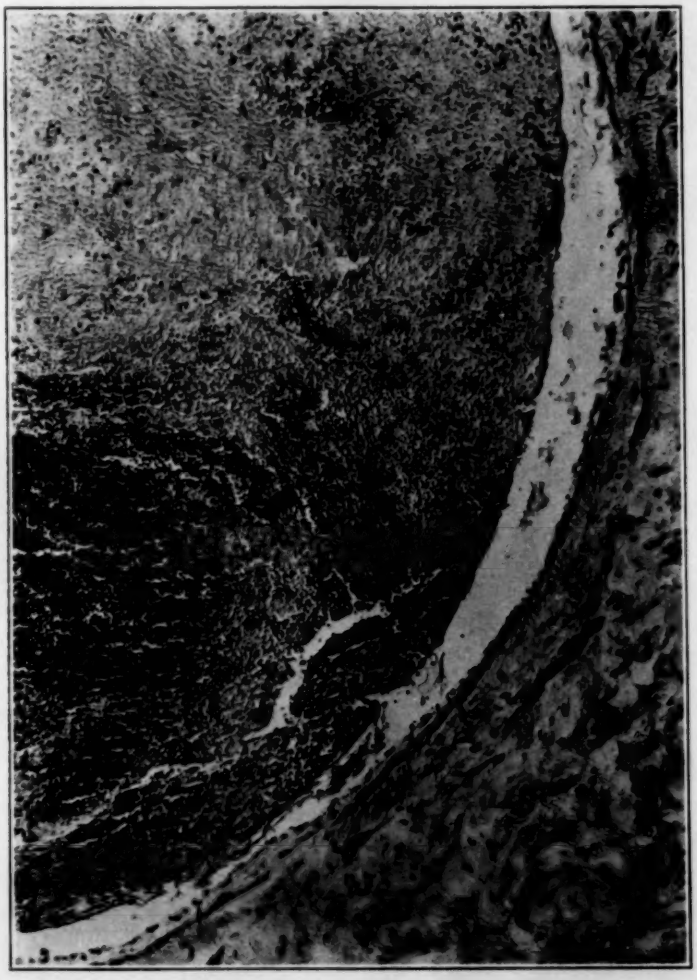

Fig. 4.—Photomicrograph of a section of a thrombus formed in a femoral vein by double partial ligation.

skin decreases the circulation time, and that coldness increases it. They stated that the venous blood flow is retarded after operation and con-

6. Smith, L. A.; Allen, E. V., and Craig, W. M.: Time Required for Blood Flow from the Arm and from the Foot of Man to the Carotid Sinus, Arch. Surg. **41**:1366-1376 (Dec.) 1940.

cluded that "This factor probably is important in the genesis of post-operative thrombosis and embolism."

Why is phlebothrombosis rare in the axillary veins if not because the rather constant action of the muscles and the frequent elevation

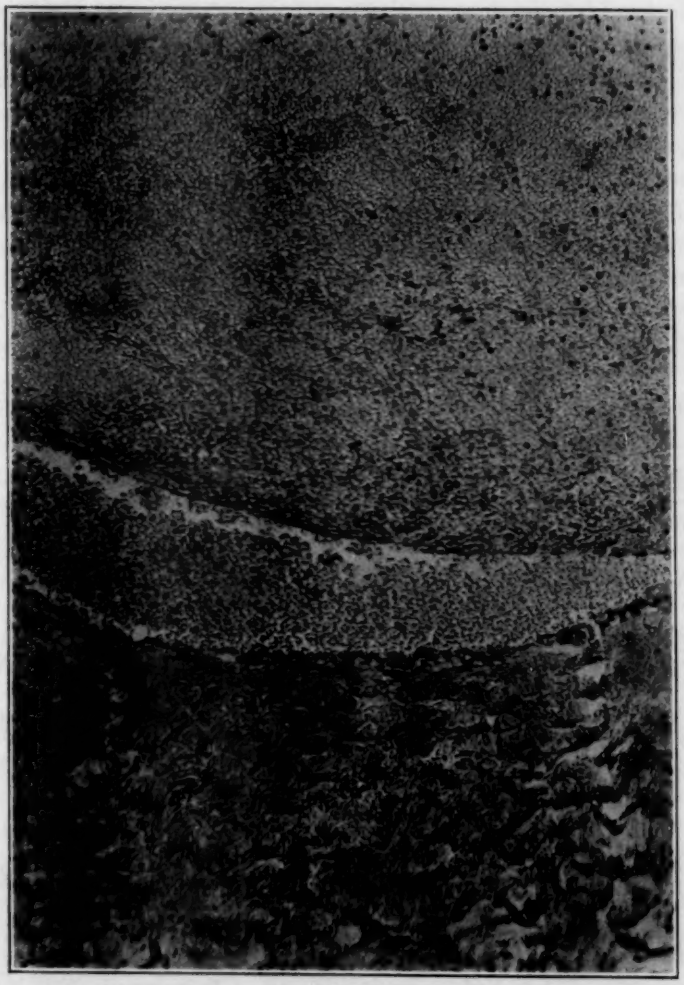

Fig. 5.—Photomicrograph of a section of a thrombus formed in an external jugular vein by complete ligation.

of the arms prevent the accumulation of clot-forming elements? Thrombosis is common in patients with fractures necessarily confined in restraining plaster encasements but rare in patients with fractures of equal severity which can be treated by ambulatory methods. The only varying factor is activity.

Cardiac weakness,[7] shallow respiration, forced inactivity, low blood pressure, abdominal distention, tight abdominal binders, pillows beneath the knees, pressure of one leg against the other, pressure of Poupart's ligament against the femoral vein—all of these in a measure combine to simulate the experimental condition of retarded circulation already described. When to these are added old age, obesity, cachexia, depression of the circulation by drugs, dehydration increasing the viscosity of the blood, varicosities in the legs, altered blood chemistry and physical depression, one wonders why phlebothrombosis and pulmonary embolism are such relatively rare postoperative complications.

During the past few decades most of the efforts toward the prevention of pulmonary embolism have been focused on the prevention of venous stasis in the legs. Krecke,[8] Pool,[9] Blair,[10] Gamble,[11] Barnes,[12] Ochsner and De Bakey [13] and others have advised postoperative breathing and leg exercises. Schmid,[14] DeCourcy,[15] Gray [16] and de Takats [17] advised elevation of the foot of the bed to aid the return of venous blood. Walters [18] increased the rate of blood flow by the administration of thyroid. In fact, there are few surgeons who do not appreciate the importance of as much activity as possible for all patients who are confined to bed.

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7. Belt, T. H.: Thrombosis and Pulmonary Embolism, Am. J. Path. **10**:129, 1934.

8. Krecke, A.: Ueber Vor- und Nachbehandlung bei Bauchoperationen, insbesondere über das frühzeitige Aufstehenlassen, München. med. Wchnschr. **57**: 2037-2041, 1910.

9. Pool, E. H.: Systematic Exercises in Postoperative Treatment, J. A. M. A. **60**:1202-1204 (April 19) 1913.

10. Blair, B., in discussion on Glynn, E.: Pulmonary Embolism, J. Obst. & Gynaec. Brit. Emp. **31**:521, 1924.

11. Gamble, H. A.: The Prevention of Postoperative Embolism and Phlebitis, Am. J. Surg. **28**:93-95, 1935.

12. Barnes, A. R.: Pulmonary Embolism, J. A. M. A. **109**:1347-1352 (Oct. 23) 1937.

13. Ochsner, A., and De Bakey, M.: Therapy of Phlebothrombosis and Thrombophlebitis, Arch. Surg. **40**:208-231 (Feb.) 1940.

14. Schmid, H. H.: Verhütung von Thrombosen und Embolien, Arch. f. Gynäk. **161**:401-404, 1936.

15. DeCourcy, J. L.: Venous Stasis as Cause of Postoperative Embolism: Its Prevention by Use of Reverse Fowler Position After Lower Abdominal Operations, Anesth. & Analg. **8**:342-345, 1929.

16. Gray, H. K.: The Use of the Trendelenburg Position in the Prevention of Postoperative Pulmonary Complications, Proc. Staff Meet., Mayo Clin. **9**:453-454, 1934.

17. de Takáts, G., and Jesser, J. H.: Pulmonary Embolism: Suggestions for Its Diagnosis, Prevention and Management, J. A. M. A. **114**:1415-1421 (April 13) 1940.

18. Walters, W.: Method of Reducing Incidence of Fatal Postoperative Pulmonary Embolism, Surg., Gynec. & Obst. **50**:154-159, 1930.

In a series of experiments [19] we demonstrated that simultaneous elevation of both hindlegs of a dog increased the rate of venous blood flow in the inferior vena cave from 100 to 250 per cent. Sweeping out of the veins the beginning of accumulations of formed elements of the blood should, if attainable, lessen the incidence of thrombosis.

Beginning in 1928, one of us (W. J. P.) decided to adopt routine breathing and leg exercises for all adult patients unless their condition was such that it seemed inadvisable. The following order is written and takes effect the evening of the operation or the morning after operation: "Have the patient take fifteen deep breaths each morning and evening and with each breath actively flex the legs." The choice of fifteen was purely arbitrary. So long as the patient goes through the night without active exercise there seemed no object in repeating them oftener than twice a day. If any scheme of postoperative activity is adopted, it must be followed through with instruction of the nursing

TABLE 2.—*Data on the Clinical Study of Pulmonary Embolism*

	Number	Phlebothrombosis	Pulmonary Infarction	Fatal Pulmonary Embolism
Postoperative patients who did breathing and leg exercises	837	0	0	0
Patients with fractures requiring immobilization of one or both legs	124	5	6	0
Postoperative patients who did no exercises	150	4	1	1

and the resident staff. Occasional meetings with the nursing and the resident staff to explain the object of this regimen is beneficial in securing cooperation. Too often the type and the amount of postoperative activity are left to the discretion of the nurse, who follows the indefinite verbal order of the surgeon to keep the patient active.

Before giving personal statistics (inconclusive because the number is small), it is fitting to quote from a previous publication: "Coincidence often leads us astray in the evaluation of therapeutic procedures." However, during the past thirteen years there has been no occurrence of phlebothrombosis or pulmonary embolism among 837 private patients who carried out the routine postoperative breathing and leg exercises. During this same period the controls consisted of two groups: (1) 124 patients with fractures which required immobilization of one or both of the extremities and (2) approximately 150 patients who after a major operation did not or were not asked to carry out the postoperative exercises (table 2). In the first control group there were 5 cases of

19. Potts, W. J., and Smith, S.: Pulmonary Embolism: An Experimental Study of Variations in the Volume Blood Flow in the Inferior Vena Cava of the Dog, Arch. Surg. **42**:661-664 (April) 1941.

phlebothrombosis, 4 of which were followed by pulmonary infarction, and 1 case of pulmonary embolism found at postmortem examination in a man who died five days after fracture-dislocation of the first lumbar vertebra complicated by transection of the cord. The origin of the emboli in this patient could not be found.

The clinical history of 1 patient not included in the group of control patients with fractures is of interest and if correctly interpreted supports the premise that inactivity is a causative factor in the production of thrombosis.

REPORT OF A CASE

Mr. V., a man aged 65, with moderately advanced Paget's disease of the right humerus, suffered a simple transverse fracture of this bone at the junction of the lower and the middle third. With the region under local anesthesia and with the aid of a fluoroscope, the fragments were replaced and fixed with molded plaster splints. The entire arm was firmly bound to the patient's chest with gauze bandage. He remained in the hospital three days but was ambulatory. Fourteen days after the fracture the patient complained of pain in the chest and spat up bright red blood. Because of the fixation apparatus adequate examination of the chest was impossible. Three days later there was recurrence of these symptoms. Both episodes were associated with fever. No sign of thrombophlebitis in the legs could be found. Dr. Robert Hemphill, the medical consultant, made a diagnosis of pulmonary infarction. Spontaneous recovery followed. The fixation apparatus was removed forty days after the fracture, when roentgenograms showed that satisfactory healing had occurred. The arm was swollen but not abnormally so, and no thrombosed veins could be palpated. In the absence of signs of thrombosis elsewhere, it seems fair to assume that the emboli originated in the veins of the immobilized arm.

In the surgical control group were 4 patients with phlebothrombosis. In 2 patients, women aged 49 and 58 respectively, thrombosis followed drainage of an appendical abscess. The woman who was 58 died instantaneously of pulmonary embolism. In a man aged 36 the phlebothrombosis followed release of mechanical intestinal obstruction, and in a woman aged 79 it followed abdominoperineal resection of the rectum. Following cholecystectomy in a woman aged 40 there was pulmonary infarction but no sign of phlebothrombosis.

To remind the nurses constantly that their patients must do the breathing and leg exercises and to demonstrate frequently to both patients and nurses how these are to be done is laborious. As a matter of fact, in the summer of 1935 they were discontinued for a time when doubts concerning their value arose. Promptly, extensive phlebothrombosis developed in a patient, and he died of pulmonary embolism (referred to already). This catastrophe, a coincidence most likely, nevertheless stimulated immediate reintroduction of routine breathing and leg exercises which have been continued since. That they are of some value there is little question. A negative virtue lies in the fact that they do

no harm. Certainly the patient who has been active in bed following an operation feels better on getting up than the patient who has been inactive.

SUMMARY

Experimentally we have demonstrated that thrombosis will occur in the femoral vein of a dog after double partial ligation.

Clinically it appears that a definite routine of postoperative breathing and leg exercises is of some value in lessening the incidence of phlebothrombosis and pulmonary embolism.

715 Lake Street.

ABSTRACT OF DISCUSSION

Dr. Géza de Takáts, Chicago: The paper emphasizes the great importance of venous stasis in the formation of thrombi and consecutive emboli. Retardation of venous return has been demonstrated repeatedly on patients after operation or immobilization. Drs. Potts and Smith have clearly shown the factors which contribute to the slowing of circulation in bedridden patients. The interference with venous return is especially marked in the frequently employed Fowler position, during which stasis is produced in the pelvis, in the groin, and in the deep and muscle veins of the calves. To overcome this, the postoperative Trendelenburg position, maintained from twenty-four to forty-eight hours, is truly a great improvement and can be used for patients who are unable to carry out simple exercises.

Dr. Lawrence Petersen has recently tabulated the mortality following major amputations at the Research and Educational Hospitals. There were 110 major amputations between 1927 and 1942, and 9 patients died, giving a mortality of 8 per cent. Only 1 patient died of embolism, and this was a person with polycythaemia vera who had been treated with leeches up to the fifth day and died on the sixth, after the use of leeches was discontinued. Only 1 patient in this group had a ligation of the femoral vein. In the experience of my associates and me, then, pulmonary embolism does not occur frequently after amputations, the incidence being not more than 1 or 2 per cent.

Recently we have attempted to study the clotting mechanism of patients by determining their response to heparin. Roughly, all individuals fall into one of three groups. Their response to heparin is normal, exaggerated, or diminished.

In spite of the great importance of venous stasis, one should not forget that coagulation of blood is favored in the postoperative state. Heparin or other anticoagulants obviously cannot be given to all postoperative patients, but the endangered group may be picked out by their response to heparin. For such patients all available measures against thrombosis must be carried out with the greatest vigor.

Dr. Edgar V. Allen, Rochester, Minn.: Theoretically there are three possible mechanisms for postoperative venous thrombosis. One of these is an increased tendency of the blood to clot. However, in spite of assiduous studies, no one has shown conclusively that there exists such an increased tendency after operation. There are some conditions of the blood which predispose to venous thrombosis following operation, but in the vast majority of patients who are operated on there are no significant changes in the coagulation of the blood after operation.

A second factor is the possibility of trauma to veins. I am told that assistants do not lean on a femoral vein during a major operation and that usually no other trauma occurs. Yet it is known that after such operations as cholecystectomy thrombosis of the femoral vein may occur. For those who advocate the theory of trauma, there is some evidence in support as shown by the fact that the incidence of postoperative venous thrombosis following pelvic operations is three times as great as the incidence following operations on the upper part of the abdomen. There is no evidence that this trauma to veins is a significant, persistent cause of postoperative venous thrombosis.

The third possibility, one which is the subject of the discussion today, is the question of slowed circulation of venous blood. As Dr. Potts has indicated, Smith and I have made studies of circulation time and have shown that after an operation there is a fairly constant reduction in the speed with which the blood flows through the veins of the lower extremities. This begins on the second or third postoperative day; the blood flows progressively more slowly through the veins of the lower extremities, until the patient becomes ambulatory.

How does this fit in with what is known about postoperative venous thrombosis? Similar studies on the circulation of blood in the veins of the upper extremities indicate that there is no significant slowing of the speed of circulation in the upper extremities. That might explain why postoperative venous thrombosis occurs so frequently in the lower extremities and so infrequently in the upper extremities. The fact that the maximum slowing of the venous circulation is on about the eighth to the twelfth postoperative day would fit in well with the observation that that is the period at which postoperative venous thrombosis occurs in the vast majority of instances. This slowed circulation of the blood in the veins would explain also why the administration of thyroid sharply decreases the incidence of postoperative venous thrombosis, and it would explain an observation which we have made that in approximately 1,200 operations (sympathectomy) for hypertension performed by neurosurgeons there has not been a single instance of postoperative venous thrombosis. Sympathectomy greatly increases the speed of flow of blood through the arteries and through the veins.

The evidence suggests that a slowed venous circulation is responsible for postoperative venous thrombosis, and Drs. Potts and Smith have added to the increasing evidence that this is true. Their evidence would be more conclusive were it not for the fact that the same procedure which produced venous thrombosis in the femoral vein failed to produce venous thrombosis in the jugular vein.

A word of caution about the interpretation of statistics. Postoperative venous thrombosis is known to occur only infrequently, and it is possible that in a large series of patients for whom nothing was done there might be no postoperative venous thrombosis merely because it does occur infrequently.

Dr. Lyman W. Crossman, New York: My associates and I in my service at the City Hospital have approached the matter of postoperative embolism in what might be considered a physiologic way. We try to prevent the formation of postoperative emboli. Dr. de Takáts discussed retarding circulation and increasing circulation. What we do is stop circulation by Frederick M. Allen's method of applying a tourniquet to the extremity 6 or 8 inches (15 to 20 cm.) proximal to the line of cutaneous incision, refrigerating the entire extremity with ice, and after two and a half hours perform an amputation with no other anesthesia. At the time of the operation we always find that the blood is fluid. We never see a blood clot.

When the stump end is about ready to be closed and the tourniquet is taken off, the blood we see is always in a liquid form. The examination of the

blood drained from the specimen as it is removed has been examined and reported as being normal. Every one of the legs so treated has been examined under the microscope by Dr. James Lisa, our pathologist, and he has found no structural change as a result of the long refrigeration or the stasis and pressure brought about by the tourniquet. The tourniquet cuts off all circulation of blood and lymph and all nerve impulses. As most tourniquets are put on there is still an arterial trickle, which allows a flow of warm blood into a refrigerated extremity, and our precautions against this may explain why our patients have never had frost bite.

Dr. Allen has always emphasized the inhibition of thrombosis by cold, and, as we stated in the ARCHIVES OF SURGERY in January 1942, our group has encountered no instance of thrombosis or embolism with this method. As our series now comprises over 100 amputations, this experience appears significant.

DR. J. ROSS VEAL, Washington, D. C.: I have been interested in the freezing of the extremities. Dr. Crossman says it is a physiologic action. Speaking of physiology of circulation after freezing, if he cuts off arterial and venous circulation he creates an ideal situation in which thrombosis should occur provided it lasts long enough. Undoubtedly one can amputate an extremity after it is frozen, or partially frozen, without pain and the patient may return to the ward and be comfortable and carry on his diet, but I do not think freezing in any way prevents thrombosis. I think it creates a field in which thrombosis might develop if it persisted long enough.

There is one remark I should like to make about high ligation. It is known that clots from other parts of the body may lodge in the lungs. There have been cases in which the embolism came from the heart or some other vein of the body than that of the femoral stump, but I feel that the majority of the pulmonary complications following thigh amputations are embolic and that the emboli arise from the stump of the femoral vein.

DR. W. J. POTTS, Oak Park, Ill.: There is a great deal of mystery about pulmonary embolism. The causes are not known.

An interesting observation was made by a man in England, published in the *Lancet* some time ago. He showed that in a large city hospital, where casualties of various kinds from London came in the number of cases of pulmonary embolism in a group of a certain size under ordinary conditions was 6, but that during air raids the number of cases of pulmonary embolism in the same number of patients increased to 24. In other words, there was a 400 per cent increase in pulmonary embolism. He concluded that the reason for this was that the people sat in chairs in the air raid shelters, with the legs dependent, which caused thrombosis. I feel certain that the mechanical factor is the large one. If one could find how the clotting mechanism varies in patients it would be helpful.

Dr. Allen many years ago made, and a few years ago I repeated, a study on the relation of platelet count and coagulation time in postoperative patients and found that the latter varied from two to ten minutes, and yet there were no cases of thrombosis. As Dr. Allen so well pointed out, the whole thing may be a matter of coincidence, which, I wish to repeat, often leads physicians astray in the evaluation of procedures.

WOUND HEALING

EFFECT OF A STERILE ABSCESS ON FIBROPLASIA IN WOUND HEALING

CAPTAIN GEORGE B. SANDERS
MEDICAL CORPS, ARMY OF THE UNITED STATES
AND
W. S. GARRISON, M.D.
PHILADELPHIA

The intermediary stages of the metabolism of endogenous protein have been the subject of considerable interest from the time of the earliest studies on the physiology and biochemistry of nutrition. Recently interest has been renewed or accentuated because of the increasing recognition of the importance of hypoproteinemic states in clinical medicine. The recent attempts by Elman, Farr and others [1] to build up tissue and plasma protein by supplying protein precursors intravenously emphasized the need for greater knowledge concerning the utilization of these materials by the organism.

One of the least understood phases in this endogenous cycle is the fate of the protein-split products released by catabolism of tissue protein. It is important to know whether these products are available, wholly or in part, for the repair of damaged tissues and for the replenishment of protein stores in the liver and the circulating plasma.

Madden and Whipple and co-workers [2] found that the presence of a sterile abscess induced by the injection of turpentine markedly delayed the regeneration of plasma protein in dogs consuming an ample diet. They felt that the sharp reduction in the curve of regeneration during the first twenty-four hours reflected in part the extravasation of plasma protein into the damaged tissues. However, they maintained that a true disturbance of the mechanism for producing plasma protein also occurred.

From the Harrison Department of Surgical Research, University of Pennsylvania, School of Medicine.

1. Elman, R., and Weiner, D. O.: Intravenous Alimentation, with Special Reference to Protein (Amino Acid) Metabolism, J. A. M. A. **112**:796 (March 4) 1939. Elman, R.: Proc. Soc. Exper. Biol. & Med. **36**:867, 1937. Farr, L. E., and McFayden, D. A.: ibid. **42**:445, 1939.

2. Madden, S. C.; Winslow, P. M.; Howland, J. W., and Whipple, C. H.: J. Exper. Med. **65**:431, 1937.

Ravdin, Goldschmidt and Vars [3] showed that diets rich in protein protected the livers of rats from damage by anesthesia induced with chloroform. They expressed the opinion that protein or some fraction of protein leads to a reduction of the amount of preexisting liver lipid which predisposes to hepatic injury by chloroform and that adequate reserves of protein would lead to more rapid regeneration following injury. They showed also that the intramuscular administration of sodium ricinoleate protects rats receiving diets deficient in protein against hepatic damage. They expressed the belief that the protein-split products liberated locally and generally by the sterile abscess are utilized by the livers of these animals to maintain or replenish their protein stores.

In the experiments to be described in this paper an attempt has been made to determine whether or not the products of protein catabolism initiated by such a process are used by the organisms for tissue repair.

Composition of the Diet Given to the Rats Used in the Experiments

	Percentage
Sucrose	55.1
Dextrin	18.2
Lard	15.0
Butter	6.5
Bone ash	2.4
Salt mixture (Osborne and Mendel)	1.2
Cod liver oil	2.0
Vegex *	5.0

* Vegex is an autolyzed yeast extract.

METHOD

The curve of velocity of fibroplasia in the healing wounds of rats was chosen as the index of tissue repair. Adult albino rats weighing between 200 and 350 Gm. were selected. The animals were maintained throughout the experimental period on a diet containing approximately 1 per cent protein; the composition of the diet is given in the table. This was done in the hope that the effect of additional protein-split products made available by sterile abscess would be more evident.

The animals were given this diet for from ten to thirteen days preoperatively. Careful records of the food eaten and the weight lost by each animal were made during this period. The animals were then subjected to simple laparotomy. The anesthetic employed was sodium amytal (0.0005 mg. per gram of body weight) given intraperitoneally. Under aseptic precautions a midline incision was made through the skin, the muscles and the peritoneum of the anterior abdominal wall. The peritoneum and the muscles were closed as a single layer by a continuous stitch of no. 000 plain catgut. The skin was closed as a separate layer, a similar suture being used. After operation the animals were again given their preoperative diets, and records of the food eaten and the weight lost were kept as before. Half the animals received 0.08 cc. of a 10 per cent solution of sodium ricinoleate

3. Goldschmidt, S.; Vars, H. M., and Ravdin, I. S.: J. Clin. Investigation **18**:277, 1939.

intramuscularly on the day of operation and on the third and sixth postoperative days. A different site for each injection was employed, the muscles of the neck and the shoulders and the upper portions of the lower extremities being chosen in succession.

Four to 6 rats from each of the two groups were killed daily, and the tensile strength of their wounds was determined. The method and the apparatus used in making these determinations were the same as those employed by Meade [4] in his studies on the tensile strength of the diaphragm. All animals showing infection in the wounds or at the site of injection were discarded.

RESULTS

Practically all the rats lost weight steadily while taking the diet low in protein but remained in good condition otherwise. There were no significant differences in weight loss or food intake between the two groups (chart 1).

The catgut skin sutures disappeared at approximately the same time (three to five days) in the two groups. Residual segments of the deep catgut sutures persisted for six to ten days in all the animals of both groups, but the suture had consistently lost its continuity by approximately the sixth day. In general, integrity of the deep sutures was maintained longer in the rats given sodium ricinoleate.

Comparatively few wound infections occurred. Those that were observed had a catgut knot for their focus. Sodium ricinoleate consistently produced a sterile abscess at the site of injection. In some instances the abscess contained a small amount of glairy translucent amber fluid. No suppuration was encountered. The abscess wall was composed of inflammatory tissue containing many fibroblasts and leukocytes. There was considerable edema of the tissues surrounding the abscess. When the sodium ricinoleate had been placed too superficially, necrosis and gangrene of the skin resulted. In 5 cases sloughing of the gangrenous skin occurred.

Spontaneous evisceration was frequent during the first five days but showed no significant difference in group incidence. Evisceration during handling and injection occurred in approximately 1 of 6 animals in the group given sodium ricinoleate. These animals were immediately killed.

There was a rather high late mortality rate during the first eight days postoperatively, in both the control animals and those given sodium ricinoleate. Examination of those animals in which evisceration was not the cause of death usually failed to show any obvious gross pathologic changes. The mortality rate was approximately the same in both groups.

The variations between the individual determinations of tensile strength were too great to permit proper statistical treatment of the figures obtained. However, the general trend of the velocity of fibro-

4. Meade, R. H.: J. Thoracic Surg. **5**:503, 1933.

plasia was obtained by plotting a curve of the average values of each group (chart 2). From the curves thus obtained a definite retardation of the velocity of fibroplasia can be seen in the group given sodium ricinoleate. The lag in fibroplasia is seen to be maximal during the

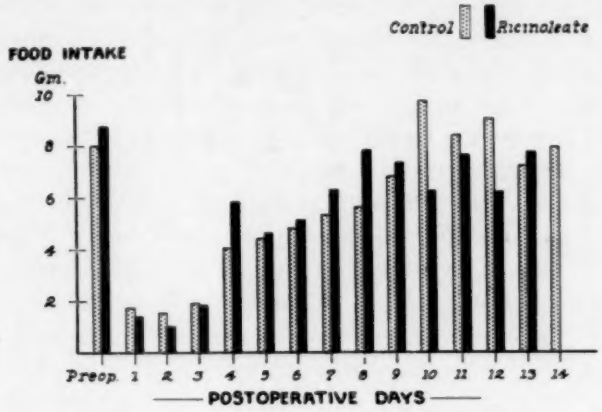

Chart 1.—Dietary intake of control rats and of those given sodium ricinoleate.

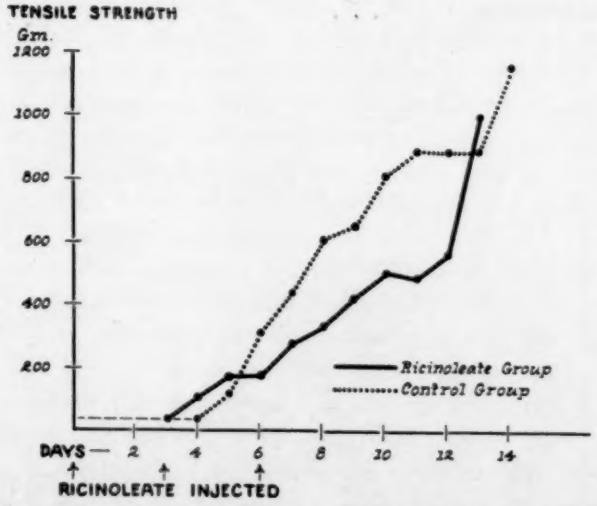

Chart 2.—Curve of velocity of fibroplasia in healing wounds of rats given a diet low in protein.

period from five to ten days after operation. The relation of the lag in fibroplasia to the period of injection of sodium ricinoleate should be noted. It also is of interest that fibroplasia began twenty-four hours earlier in the group given sodium ricinoleate than in the control group. The individual variations in tensile strength in the control group and the group given sodium ricinoleate are shown in charts 3 and 4.

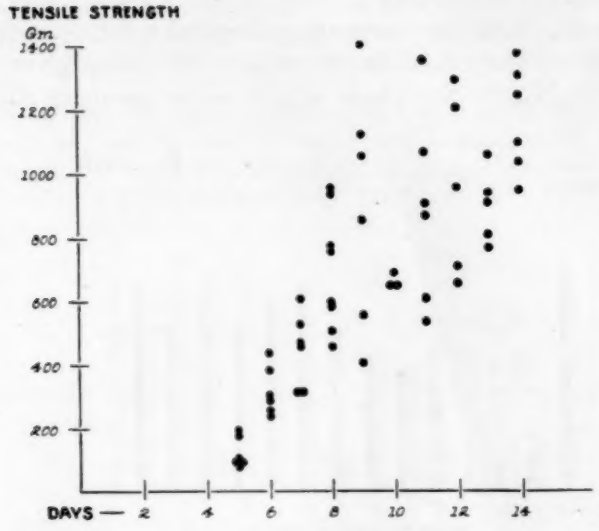

Chart 3.—Determinations of the tensile strength of wounds of rats in the control group.

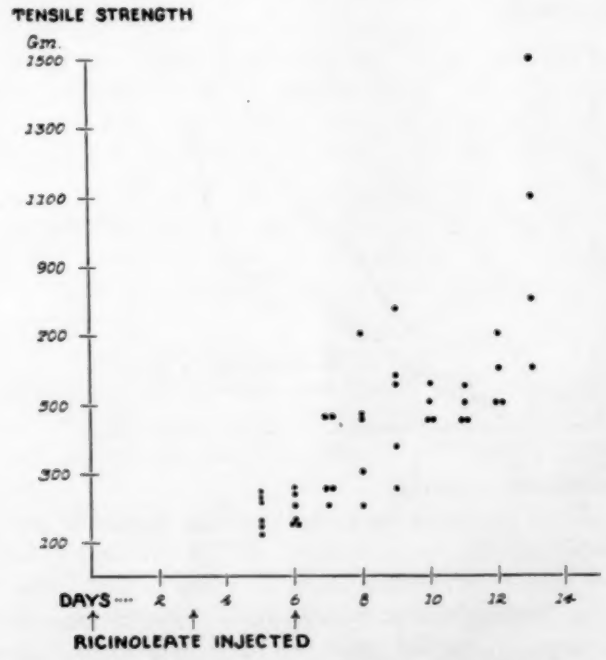

Chart 4.—Determinations of the tensile strength of healing wounds of rats given sodium ricinoleate.

COMMENT

Studying the rate of cicatrization of wounds in dogs, Clark [5] reported that the feeding of diets high in protein abolished the latent period of cicatrization so that fibroplasia began immediately. With an adequate mixed diet the latent period was four days. A diet high in fat and low in protein increased the latent period to six days.

The careful experiments of Harvey and Howes [6] showed that feeding diets high in protein increases the velocity of fibroplasia in the healing stomach wounds of rats. The latent period was not affected in their experiments. They reported also that partial or complete starvation of adult rats at first caused a definite lag in fibroplasia during the first ten days but that a compensatory acceleration occurred during the last phase of the healing process which more than compensated for the initial lag. It is important in the light of the present experiments to emphasize that increased endogenous catabolism of protein in the starved and semistarved animals was stated by Harvey and Howes to be responsible for this acceleration.

In the present experiments it was hoped that a greater lag in fibroplasia would be produced by feeding a diet low in protein and that consequently the accelerating effect, if any, of endogenous protein catabolism would be magnified. In the experiments of Harvey and Howes [7] the increase in endogenous tissue breakdown was the result of starvation and appeared during the last phase of the healing process. In the present experiments, breakdown of tissue has been greatly increased by the injection of sodium ricinoleate and has been marked within twenty-four hours after the first injection or, in other words, by the end of the first postoperative day.

Comparison of the curves of velocity of fibroplasia in the two groups suggests that the injection of sodium ricinoleate retarded rather than accelerated fibroplasia. The general similarity of the two curves should be noted. The lag in fibroplasia in the animals given sodium ricinoleate occurs entirely in the first portion of the curve before it reaches a horizontal phase at the tenth day. In both curves there is a sharp increase in the velocity of fibroplasia after the twelfth and thirteenth days, respectively. It is interesting to observe that, in point of phase,

5. Clark, A.: Bull. Johns Hopkins Hosp. **30**:117, 1919.

6. Harvey, S. C.: Velocity of Growth of Fibroblasts in Healing Wound, Arch. Surg. **18**:1226 (April) 1929. Harvey, S. C., and Howes, E. L.: Ann. Surg. **91**:641, 1930. Howes, E. L.; Briggs, H.; Shea, R., and Harvey, S. C.: Effect of Complete and Partial Starvation Rate of Fibroplasia in Healing Wound, Arch. Surg. **23**:846 (Nov.) 1933.

7. Howes, E. L.; Harvey, S. C., and Hewitt, C.: Rate of Fibroplasia and Differentiation in Healing of Cutaneous Wounds in Different Species of Animals, Arch. Surg. **38**:934 (May) 1939.

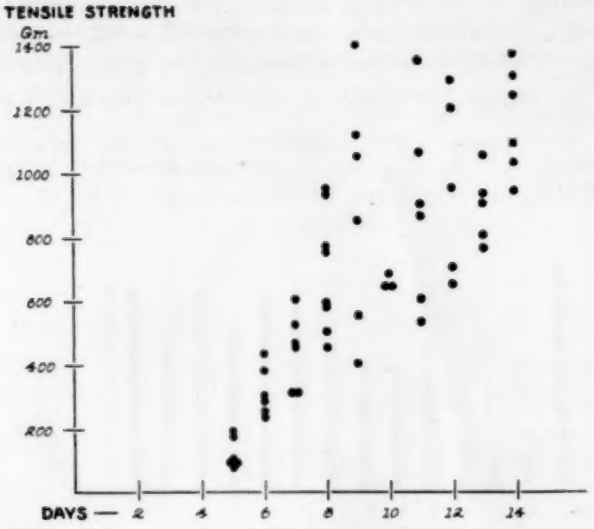

Chart 3.—Determinations of the tensile strength of wounds of rats in the control group.

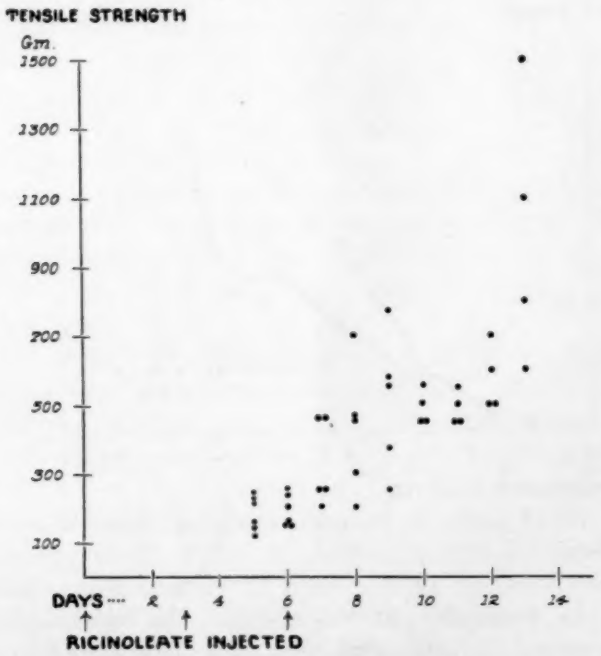

Chart 4.—Determinations of the tensile strength of healing wounds of rats given sodium ricinoleate.

COMMENT

Studying the rate of cicatrization of wounds in dogs, Clark [5] reported that the feeding of diets high in protein abolished the latent period of cicatrization so that fibroplasia began immediately. With an adequate mixed diet the latent period was four days. A diet high in fat and low in protein increased the latent period to six days.

The careful experiments of Harvey and Howes [6] showed that feeding diets high in protein increases the velocity of fibroplasia in the healing stomach wounds of rats. The latent period was not affected in their experiments. They reported also that partial or complete starvation of adult rats at first caused a definite lag in fibroplasia during the first ten days but that a compensatory acceleration occurred during the last phase of the healing process which more than compensated for the initial lag. It is important in the light of the present experiments to emphasize that increased endogenous catabolism of protein in the starved and semistarved animals was stated by Harvey and Howes to be responsible for this acceleration.

In the present experiments it was hoped that a greater lag in fibroplasia would be produced by feeding a diet low in protein and that consequently the accelerating effect, if any, of endogenous protein catabolism would be magnified. In the experiments of Harvey and Howes [7] the increase in endogenous tissue breakdown was the result of starvation and appeared during the last phase of the healing process. In the present experiments, breakdown of tissue has been greatly increased by the injection of sodium ricinoleate and has been marked within twenty-four hours after the first injection or, in other words, by the end of the first postoperative day.

Comparison of the curves of velocity of fibroplasia in the two groups suggests that the injection of sodium ricinoleate retarded rather than accelerated fibroplasia. The general similarity of the two curves should be noted. The lag in fibroplasia in the animals given sodium ricinoleate occurs entirely in the first portion of the curve before it reaches a horizontal phase at the tenth day. In both curves there is a sharp increase in the velocity of fibroplasia after the twelfth and thirteenth days, respectively. It is interesting to observe that, in point of phase,

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7. Howes, E. L.; Harvey, S. C., and Hewitt, C.: Rate of Fibroplasia and Differentiation in Healing of Cutaneous Wounds in Different Species of Animals, Arch. Surg. **38**:934 (May) 1939.

the curve of the group given sodium ricinoleate consistently precedes that of the controls by twenty-four hours. Thus, fibroplasia begins on the third day in the group given sodium ricinoleate and on the fourth day in the controls. The horizontal phase in the curve is reached by the tenth day in the animals given sodium ricinoleate, and not until the eleventh day in the controls. The secondary, compensatory rise in

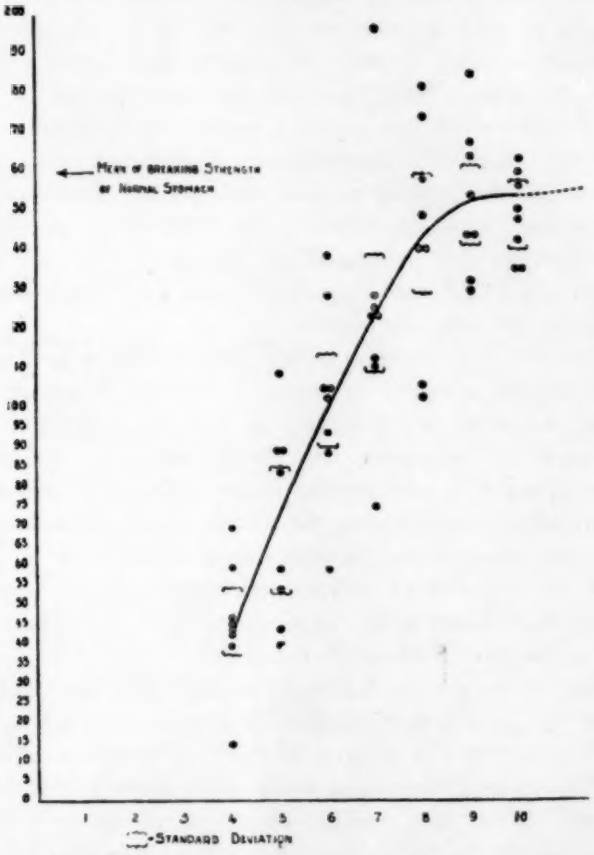

Chart 5.—Curve of velocity of growth of fibroblasts in healing wound of the stomach of the rat (after Harvey).

fibroplasia begins at twelve days in the group given sodium ricinoleate and at thirteen days in the control group, reaching average values of 1,000 and 1,160 Gm., respectively. The average tensile strength of the intact abdominal wall of rats fed for twenty-five days with the diet low in protein has been determined by the present methods to be 2,300 Gm. In Harvey's calculations the tensile strength developed in the healing wounds of the rat's stomach approximated that of the intact stomach by the tenth day (chart 5). Similar experiments on the tensile

strength of cutaneous wounds in the rat revealed that the incised wounds did not develop tensile strength equal to that of the intact skin until well past twenty days (chart 6).[7]

The criticism may be made that determinations of the tensile strength of a layered wound, such as an incised wound of the abdominal wall, cannot be expected to give uniformly significant results. Actually, however, only the strength of the musculofascial union, which functioned as a single layer, was tested in these studies. The cutaneous wound

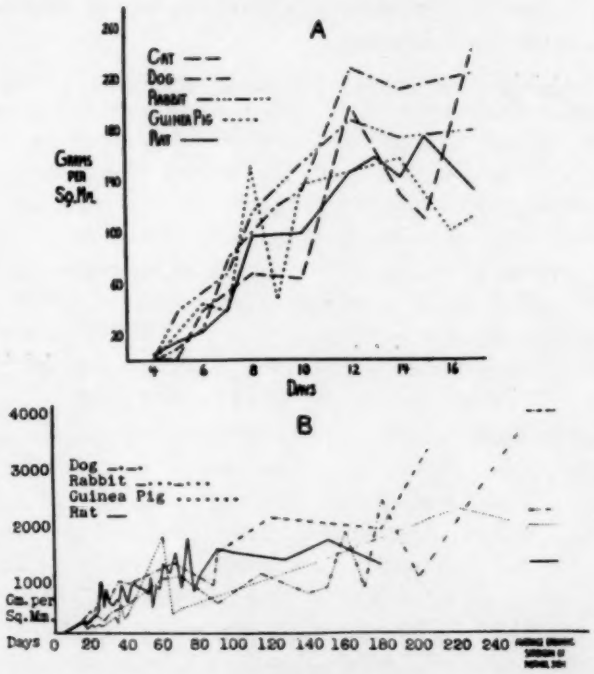

Chart 6.—*A*, early breaking strength of cutaneous wounds; *B*, later breaking strength of cutaneous wounds (after Howes, Harvey and Hewitt).

invariably gave way before the main wound, usually at a tension 200 to 300 Gm. less than the final calculation of tensile strength.

It is to be regretted that the curves of fibroplasia were not followed for at least ten to fifteen days more. Ravdin, Vars and Goldschmidt [8] demonstrated storage and utilization by the liver of the protein-split products liberated from sterile abscesses in the rat. There may well be an intermediate hepatic phase in the endogenous catabolism of tissue protein, which must take place before these products of protein degeneration can be utilized by the organism for tissue repair.

8. Ravdin, I. S.; Vars, H. M., and Goldschmidt, S.: J. Clin. Investigation **18**:633, 1939.

CONCLUSIONS

The presence of a sterile abscess retards the velocity of fibroplasia in the healing wounds of rats on a diet low in protein.

This effect is most noticeable during the period from the fifth to the tenth day after operation.

No evidence is furnished by the results of these experiments that protein-split products liberated by the breakdown of tissue in the formation of a sterile abscess are utilized in wound healing.

A hepatic phase in the cycle of endogenous protein catabolism may be necessary before such protein-split products can be utilized by the organisms to repair damaged tissue.

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FATE OF PROCAINE IN THE HUMAN BODY AFTER SUBARACHNOID INJECTION

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The great increase in the use of spinal anesthesia during the past two decades has been accompanied by a corresponding increase in the number of studies relating to its clinical aspects. But the basic question of the dynamics and fate of the drug itself has not been adequately treated. We therefore embarked on a program designed to develop and utilize trustworthy technics which would enable us to trace the course of the drug, determine what changes, if any, it underwent and find the site and the mechanism of these changes. While this program has not been completely fulfilled, we believe sufficient information has been gained to assist materially in the understanding of spinal and local anesthesia induced by procaine hydrochloride.

The first step was the development of a delicate analytic method for the determination of procaine in the various body fluids. Since it soon appeared that the procaine is rapidly detoxified, it was necessary to develop several supplementary procedures to enable us to distinguish each of the products of detoxication separately.

The basic reaction on which all the determinations reported here were based is the classic diazotization followed by coupling with an aromatic amine. The resultant dye is determined colorimetrically. When the determination is carried out thus on a native body fluid, the fraction is merely designated "free" and does not necessarily correspond to any single chemical entity. To determine procaine one makes the fluid alkaline with sodium carbonate and extracts it with ether. The ether solution is extracted with acid, and the diazotization reaction is carried out on the acid solution.

The alkaline solution remaining after the ether extraction may be acidified and diazotized in the usual way. The value thus obtained is the best measure of the amount of procaine which has been hydrolyzed.

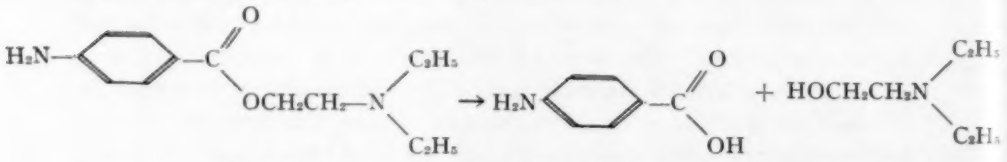
"Total" designates the sum of the free aromatic amines and the acetylated or otherwise blocked amines which are hydrolyzed by boiling

From the Richard Morton Koster Research Laboratory.

with hydrochloric acid. All values are expressed in terms of procaine equivalent.

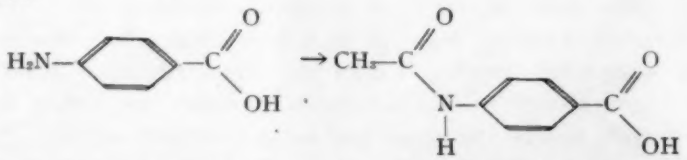
When it is desired to determine a small amount of acetylated product in the presence of a much larger concentration of "free" substance, the following procedure is used: The diazotization is carried out as usual, but instead of proceeding with the coupling one heats the solution to destroy the diazonium salt and at the same time hydrolyze the acetylated portion. Then a second diazotization is carried out, followed by the usual coupling and the colorimetric determination. The details of these procedures will be reported in a subsequent communication.

Before we present our results it may be desirable to summarize some of the possible biochemical reactions of procaine. Procaine may be hydrolyzed at the ester link to yield paraaminobenzoic acid and diethylaminoethanol. This reaction takes place slowly in pure water, but it may be accelerated by acid, alkali or other catalysts.



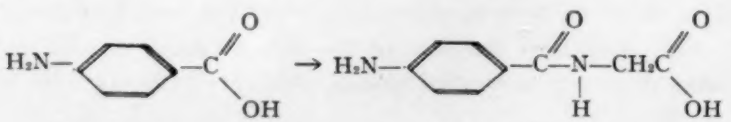
Procaine — Paraaminobenzoic Acid — Diethylaminoethanol

The products, paraaminobenzoic acid and diethylaminoethanol, are pharmacologically inert. Diethylaminoethanol can conceivably enter into a number of different reactions, but since distinctive analytic tests for it are lacking, its behavior in the body is at present unknown. It may well be excreted unchanged. On the other hand, paraaminobenzoic acid possesses functional groups the behavior of which in the body has been thoroughly studied. Like other aromatic amines, it may condense with acetic acid.



Paraaminobenzoic Acid — Paraacetaminobenzoic Acid

In analogy with the well known reaction of benzoic acid, the carboxyl group may condense with aminoacetic acid, yielding paraaminohippuric acid.



Paraaminobenzoic Acid — Paraaminohippuric Acid

It is also known that a small percentage of ingested benzoic acid is excreted as the glycuronate. The same reaction may be expected in the case of the paraamino derivative. It is also conceivable that a hydroxyl group may be introduced into the nucleus, subsequently conjugating with glycuronic acid in a glucosidic linkage.

The fall in concentration of procaine following intrathecal injection has been the subject of several papers. It has been shown that at the site of injection there is a rapid initial fall in concentration which is clearly attributable to turbulent mixing of the injected solution with the spinal fluid.[1] But there is as yet no convincingly demonstrated explanation for the slow but important fall which is responsible for the limited duration of the anesthesia. Koster, Shapiro, Warshaw and Margolick[2] have shown that it is possible to recover two thirds of an injected dose five minutes later by draining and washing out the subarachnoid space but that at the termination of anesthesia (about one hour later) less than 10 per cent is recoverable. Among the theories put forward at various times to explain the disappearance of the drug are fixation on nerve tissue, vascular absorption and hydrolysis to paraaminobenzoic acid. A possibility which has not been considered thus far is the formation of an acetylation product, either acetylprocaine or paraacetaminobenzoic acid.

The last two theories (hydrolysis and acetylation) were tested directly by analyzing samples of spinal fluid taken from patients under spinal anesthesia. The data obtained are summarized in table 1 and show that even when the anesthesia is wearing off about 97 per cent of the drug still present in the spinal fluid has undergone no change. About 2 per cent has been hydrolyzed and less than 0.5 per cent acetylated. These two theories may therefore be ruled out.

To check the validity of the other two theories, namely, the fixation and the vascular absorption theory, it is instructive to consider the results of analyses done on samples of blood taken at various intervals after the injection of procaine hydrochloride (table 2). It will be seen that although the concentration of procaine plus products of detoxication (total) is low (1 to 8 parts per million) the amount present in the 5 or 6 liters of circulating blood is not inconsiderable. In each case 5 to 10 per cent of the drug is accounted for. What is the fate of the

1. Küstner, H., and Eissner, W.: München. med. Wchnschr. **77**:622, 1930. Koster, H.; Shapiro, A., and Leikensohn, A.: Am. J. Surg. **33**:245, 1936; Concentration of Procaine in Cerebrospinal Fluid of Human Being After Subarachnoid Injection, Arch. Surg. **37**:603 (Oct.) 1938. Koster, H.; Shapiro, A., and Warshaw, R.: Concentration of Procaine in Cerebrospinal Fluid of Human Being After Subarachnoid Injection, ibid. **39**:97 (July) 1939.

2. Koster, H.; Shapiro, A.; Warshaw, R., and Margolick, M.: Removal of Procaine from Cerebrospinal Fluid During Anesthesia, Arch. Surg. **39**:682 (Oct.) 1939.

remaining 90 per cent? It seems most probable that it is dispersed uniformly throughout all the body fluids, just as is the case with the closely related sulfanilamide.[3] In the last column of table 2 are presented the amounts of total products of detoxication estimated to be present in the total body water of each patient, the concentration being assumed to be equal to that in the blood. To verify the dispersion of the products of detoxication in this manner three experiments were done in which 300 mg. of paraaminobenzoic acid was injected intravenously into

TABLE 1.—*Hydrolysis and Acetylation in Spinal Fluid*

Patient	Time of Tap, Min.	Procaine Hydrochloride, Mg. per Ce. of Cerebrospinal Fluid	Percentage of Total Hydrolyzed	Percentage of Total Acetylated
Wa.	34	1.00	2.4	0.11
Be.	40	1.05	2.0	....
An.	45	1.25	1.3	0.23
In.	58	0.64	1.9	....
La.	60	1.37	1.8	....
Ag.	72	0.44	2.5	0.45

TABLE 2.—*Blood Analyses During Spinal Anesthesia*

Patient	Dose of Procaine Hydrochloride, Mg.	Minutes After Spinal Anesthesia	Procaine, Mg. per 100 Ce.	"Total," Mg. per 100 Ce.	"Total" Mg. per 50 Liters of Body Water
Ta.	150	30	.....	0.08	40
		60	.....	0.14	70
		90	.....	0.14	70
La.	300	60	0.000	0.60	300
Fr.	450	60	.....	0.85	425
Re.	300	41	0.013	0.40	200
		74	0.016	0.42	212
Se.	300	48	0.004	0.42	208
		98	0.003	0.53	264
Ir.	300	12	0.009	0.14	68
		60	0.010	0.39	196

human subjects and samples of blood were withdrawn at short intervals thereafter. The results showed that about 90 per cent of the substances had left the blood stream in five to ten minutes. This is the fraction to be expected if the amounts of paraaminobenzoic acid in all the body fluids were in equilibrium, since the blood volume is roughly 10 per cent of the body water.

3. So uniform is the distribution of sulfanilamide that it has been proposed by E. E. Painter (Am. J. Physiol. **129**:744, 1940) as an agent for the experimental determination of body water. It is interesting to note the opinion of Dunlop [9] that in the dog procaine itself "is very rapidly removed from the blood by the tissues until equilibrium is reached between the tissues and the blood in respect to concentration of procaine."

It seems clear, therefore, that vascular absorption of the procaine is the primary reason for the fall in concentration in the spinal fluid. A residual 10 or 20 mg. of procaine may be recovered from the spinal fluid at the termination of anesthesia by the technic already mentioned.[2] While our findings do not elucidate the mechanism of the production of anesthesia, they indicate that if procaine is indeed "fixed" in the nerve tissue the total amount necessary must be relatively small.

Several authors have asserted that many of the striking phenomena accompanying spinal anesthesia are due to the presence of high concentrations of procaine in the blood:

> The dosage of novocaine [procaine hydrochloride] is so high that the amount absorbed into the blood causes a general analgesic state, and the itching, drowsiness and stupidity of the patient, which has been described by various observers, is evidence of the action of the circulating drug on the sensory nerve endings in the skin and on the cortical cells of the cerebrum. . . . All the novocaine absorbed into the blood before this begins serves only to poison the patient and effects no useful purpose.[4]

> Once the fact of [vascular] absorption is accepted, the untoward effects of spinal anesthesia might be explained on a simple pharmacologic basis. It will explain the nausea and vomiting (in the absence of abdominal manipulation and psychic causes), the intense itching occurring well above the level of anesthesia in some patients, the fall in pulse seen so frequently (probably due to the well-established depressant action of novocain on the heart musculature) and respiratory depression or failure by its action on the respiratory center. All these phenomena are known to occur after accidental intravenous injection of novocain.[5]

If procaine does indeed circulate in the manner indicated, it should respond to suitable chemical tests. The data in table 2 show that even after two or three times the usual dose of procaine hydrochloride the maximum concentration in the blood was only 0.016 mg. per hundred cubic centimeters. It is known that in experimental animals when rapid intravenous injection is used a dose of about 20 mg. per kilogram of body weight must be reached before toxic symptoms begin to be discernible. It should be appreciated that immediately after the injection the concentration of procaine in the animal's blood must approach 25 mg. per hundred cubic centimeters, or fifteen hundred times the highest concentration ever observed in the blood of a human being under spinal anesthesia. Moreover, if the drug is allowed to enter the blood stream slowly (as is the case in spinal anesthesia), as much as 400 mg. per kilogram of body weight may be administered with impunity.[6] Finally, attention is called to the report of MacDonald[7] that "the full spinal

4. Jones, W. H.: Brit. M. J. **2**:488, 1931. Wright, A. D., and Adams, A. W.: ibid. **2**:212, 1931.

5. Nowak, S. J. G.: Anesth. & Analg. **12**:232, 1933.

6. Hatcher, R. A., and Eggleston, C.: J. Pharmacol. & Exper. Therap. **8**:385, 1916.

7. MacDonald, A. D.: Lancet **1**:756, 1937.

dose" was injected directly into the veins of a human being "without ill effect."

In summary, we believe we are justified in stating that no appreciable concentration of procaine is built up in the blood during spinal anesthesia and that even if the concentration were several times the actual one it would not produce the effects attributed to it by the proponents of the toxic absorption theory.

Ever since the work of Hatcher and Eggleston [6] it has been accepted that the liver is charged with the function of detoxifying procaine. Goodman and Gilman [8] stated: "There is abundant proof that the liver is the site of destruction of the local anesthetics." Dunlop,[9] working with dogs, verified the important role of the liver and claimed that a Starling heart-lung preparation also had some slight activity. However, in a control experiment he found that blood was completely inactive.

TABLE 3.—*Hydrolytic and Acetylating Action of Human Blood on Procaine Hydrochloride in Vitro* *

Time of Incubation	Percentage Hydrolyzed		Percentage Acetylated	
	Unheated Blood	Heated Blood	Unheated Blood	Heated Blood
5 min.	52	24	..	..
30 min.	98	79	..	..
21 hr.	..	..	94	0

* Fifty cubic centimeters of blood plus 1 cc. of 12 per cent sodium citrate solution was incubated at 37 C. with 3 mg. per hundred cubic centimeters of procaine hydrochloride; half of the blood was inactivated at 56 C. for three hours.

Our own experiments, limited thus far to blood of human beings and dogs, are not in agreement with this view. In table 3 we summarize a typical experiment carried out with a sample of normal human blood. The blood was incubated with procaine hydrochloride in a concentration of 3 mg. per hundred cubic centimeters. This is the concentration which would result if 150 mg. of procaine hydrochloride (one average dose) were diluted to 5 liters, the blood volume of the adult human being. In this experiment 50 per cent of the drug was detoxified in the first five minutes. In other experiments even greater activity was shown, but in one in which a concentration of 21 mg. per hundred cubic centimeters was taken, it required two hours of incubation to hydrolyze 72 per cent of the procaine. Three samples of canine blood were tested. Each sample showed definite activity, although far less than the human samples.

8. Goodman, L., and Gilman, A.: Pharmacological Basis of Therapeutics: A Textbook of Pharmacology, Toxicology and Therapeutics for Physicians and Medical Students, New York, The Macmillan Company, 1941.

9. Dunlop, J. G.: J. Pharmacol. & Exper. Therap. **55**:464, 1935.

Can the discrepancy between our work and the work of Dunlop and Hatcher and Eggleston be reconciled? Dunlop described a single incubation experiment which "showed that blood alone has no effect on procaine." In a similar experiment with canine blood but with the use of our analytic methods, we found 30 per cent of the procaine destroyed. This difference of 30 per cent was perhaps within the limits of error of Dunlop's test, which he admitted was "only an approximate quantitative estimate." However, the use of smaller concentrations of drug leads to a much larger percentage of destruction. It is unfortunate that the relative insensitivity of the alkaline betanaphthol reagent apparently did not permit the use of lower concentrations.

"In order to test whether the blood fixes novocaine," Hatcher and Eggleston chose a far higher concentration (375 mg. per hundred cubic centimeters of the dog's blood) and reinjected the blood into the dog. The fact that the dog showed the symptoms to be expected if none of the drug had been destroyed was taken as evidence that the blood did not "fix" procaine. Hatcher and Eggleston apparently did not consider an enzymatic effect since they seem to have reinjected the blood promptly without any incubation. Obviously, this is a rough test at best and can indicate only the destruction of a large proportion of the procaine.

In the course of our experiments on detoxification in vitro it was noted not only that the procaine was hydrolyzed but that there was a diminution in the value for free amino groups, this process usually approaching completion in about twenty hours. Hydrolysis with hydrochloric acid, however, regenerated the free amino group. It is most probable that the process is an acetylation, but this is somewhat difficult to prove.[10] Confirming this assumption is the fact that dog's blood does not show this power of blocking the amino group. It is well known that dogs do not acetylate aromatic amines. However, the process seems to be relatively slow as compared with hydrolysis, and it is impossible even to guess whether the acetylation which takes place in the blood represents a major or a minor fraction of the acetylation which occurs in the body as a whole.

Separate experiments were carried out to determine whether or not the processes were of an enzymatic nature. It was found that heating the blood to 56 C. for three hours inhibited hydrolysis of the procaine, while the acetylating mechanism was completely destroyed. Addition of 0.3 per cent sodium fluoride likewise inhibited both mechanisms. These facts strongly suggest that the reactions are enzymatic in nature.

10. It should be noted that an acetate concentration of only 0.65 mg. per hundred cubic centimeters is theoretically necessary for the complete conversion of all the paraaminobenzoic acid to the acetamino derivative. Preliminary experiments to determine whether the addition of sodium acetate would accelerate the reaction were inconclusive and had to be abandoned for lack of time.

TABLE 4.—*Urinary Excretion of Procaine Detoxication Products After Subarachnoid Injection of Procaine Hydrochloride*

Patient	Procaine Hydrochloride Injected, Mg.	Hours After Injection	Urine, Cc.	Total Detoxication Product, Mg.	Percentage Acetylated	Percentage Free	Procaine Hydrochloride, Mg.	Percentage Recovered (Cumulative)
Fr.	150	2	152	60.0	94.5	5.5	0.17	40.0
		4	61	46.4	98.5	1.5		71.0
		8	78	23.4	99.2	0.8		86.2
		24	285	14.8	98.6	1.4		96.4
		48	540	4.0	....	...		....
Total				148.6				99.0
Ja.	150	2	57	26.8	94.1	5.9	0.48	17.9
		4	11	11.14	98.2	1.8		25.3
		8	73	8.2	98.8	1.2		30.4
		24	295	75.0	99.4	0.6		80.6
		48	365	7.3	....	...		85.8
		72	440	1.94	....	...		....
Total				130.38				87.0
Be.	150	2	89	0.42	100.0	0.0	....	0.28
		4	29	9.1	98.0	2.0		6.3
		8	133	89.6	98.1	1.9		66.2
		24	457	16.7	88.0	12.0		77.4
		48	780	12.8	....	...		85.9
		72	550	5.5	....	...		....
Total				134.12				89.5
Ro.	150	6	122	97.6	96.0	4.0	....	65.2
		24	368	35.2	90.5	9.5		88.5
		48	404	5.0	....	...		....
Total				137.8				91.8
Gr.	150	6	1,110	77.6	100.0	0	....	51.8
		24	720	57.0	99.1	0.9		....
Total				134.6				89.6
Saz.	150	6	98	60.0	99.6	0.4	....	40.0
		24	360	47.6	98.5	1.5		....
Total				107.6				71.7
Say.	150	6	205	59.4	100.0	0	....	39.6
		24	1,100	75.2	100.0	0		89.9
		48	670	2.68	....	...		....
Total				137.28				91.6
Po.	150	6	700	79.2	98.6	1.4	....	52.9
		24	750	24.4	96.5	3.5		....
Total				103.6				69.2
Am.	150	6	76.5	99.6	93.6	6.4	....	66.5
		24	360	27.4	96.0	4.0		84.6
		48	585	3.5	....	...		....
Total				130.5				86.7
Ob.	150	6	223	115.0	98.4	1.6	0	76.7
		24	372	19.4	99.1	0.9		98.6
		48	905	1.18	....	...		....
Total				135.58				90.4
Sc.	300	24	192	124.0	97.9	2.1	0.26	41.3
		48	600	129.24	97.8	2.2		....
Total				253.24				84.4

TABLE 4.—*Urinary Excretion of Procaine Detoxication Products after Subarachnoid Injection of Procaine Hydrochloride—Continued*

Patient	Procaine Hydrochloride Injected, Mg.	Hours After Injection	Urine, Cc.	Total Detoxication Product, Mg.	Percentage Acetylated	Percentage Free	Procaine Hydrochloride, Mg.	Percentage Recovered (Cumulative)
Ir.	300	1	44	4.84	85.0	15.0	0.39	1.6
		8	140	182.8	97.5	2.5		62.5
		24	370	50.2	98.7	1.3		79.3
		48	430	8.78	....	...		....
Total				246.62				82.2
As.	300	8	206	207.6	96.3	3.7	....	69.2
		24	176	36.4	94.8	5.2		81.3
		48	160	3.0	....	...		....
Total				247.0				82.3
Fr.	450	8	142	185.8	97.8	2.2	....	42.0
		24	330	190.8	96.6	3.4		83.7
		48	1,025	73.4	....	...		....
Total				450.0				100.0

It is at once obvious that if our experiments on the destruction of procaine by blood in vitro are accepted the experiments on the subject already in the literature must be reevaluated. Whether tests are carried out with organ mashes or by perfusion technics, the hydrolytic activity of the blood must be considered. It is also clear that the great difference between the activity of canine and human blood makes the value of experiments on dogs dubious. We have not had an opportunity to examine other species which might approximate man more closely. Nevertheless, we do not doubt that the liver also is capable of hydrolyzing procaine. It would be surprising if this great manufactory of esterase were incapable of doing this. The liver may in fact be the source of the esterase present in the blood.

For measuring the rate of excretion of the drug postoperative samples of urine were collected by means of an indwelling catheter. A preoperative sample was also taken to insure the absence of any possible interfering substances due to earlier medication. The first result to be noted is the practical absence of procaine in the urine (table 4). This, however, should occasion no surprise, as it is known that even shortly after the injection nearly all the drug present in the blood is already detoxified. Although procaine itself is practically absent from the urine, nevertheless the detoxification products are found in quantities corresponding to about 90 per cent of the injected drug. This is a relatively high percentage, considering the small quantity of drug and the manifold biologic and technical factors which might lead to incomplete recovery. Whether any portion of the drug is excreted in feces or sweat or by any other route has not been investigated.

The exact chemical composition of the products of detoxification is difficult to determine, but fractionation at varying p_H's leads us to believe

that about 2 per cent is excreted as paraaminobenzoic acid and about 30 per cent as paraacetaminobenzoic acid, the remainder being made up of paraacetaminobenzoyl glycine and paraacetaminobenzoyl glycuronate.

SUMMARY

By means of new chemical technics it is shown that procaine within the subarachnoid space remains essentially unchanged. The fall in concentration of procaine, which is responsible for the wearing off of anesthesia, is due to vascular absorption.

Once in the blood stream procaine is rapidly hydrolyzed (detoxified) by an enzyme.

There is also a less active enzyme which acetylates the free amino group.

At no time is there any appreciable trace of procaine in the blood; hence, the cause of various "toxic" effects which have been attributed to a procainemia must be sought elsewhere.

The products of detoxication leave the blood stream rapidly until equilibrium is approached between the blood and all the other tissues.

Nearly all the injected procaine (90 per cent on the average) is excreted in the urine, but only in the form of products of detoxication more or less equally divided between paraacetaminobenzoic acid, paraacetaminohippuric acid and paraacetaminobenzoyl glycuronate.

40 Maple Street.

THORACOABDOMINAL GUNSHOT WOUNDS

A REVIEW OF EIGHTY-FOUR CASES

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Thoracoabdominal gunshot wounds are grave injuries which must be carefully studied and energetically treated. A penetrating projectile has no respect for fascial planes or divisions between body cavities; hence a combined lesion must be considered in all wounds of the lower portion of the thorax and the upper portion of the abdomen. Because of the great physiologic difference in the character of the abdominal and the thoracic cavity, injury to both as occurs in a penetrating wound contributes more profoundly to the patient's shock than injury to either of the cavities alone.

Thoracoabdominal penetrating wounds are common lesions during warfare. This type of lesion constituted 9 per cent of thoracic wounds and 12 per cent of abdominal wounds seen at the casualty-clearing stations of the British Expeditionary Forces in World War I according to MacPherson and associates,[1] Taylor[2] and Wallace and Fraser.[3] Jolly[4] found that 11 per cent of abdominal wounds in evacuation hospital units during the Spanish civil war were combined lesions. Heyd[5] reported that 10 per cent of the patients with wounds of the chest had wounds of the diaphragm and that 12 per cent of the patients with abdominal wounds seen by him in the American Expeditionary Forces of World War I had comcomitant injuries of the chest. Lee,[6] however,

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1. MacPherson, W. G.; Wallace, C.; Bowlby, R. A., and English, C.: Official History of the War Medical Services: Surgery of the War, London, His Majesty's Stationery Office, 1922, vol. 1.

2. Taylor, G.: Abdominothoracic Wounds of Warfare, Brit. M. J. **2**:131-134 (Aug. 2) 1919.

3. Wallace, C., and Fraser, J.: Surgery at a Casualty Clearing Station, London, A. & C. Black, Ltd., 1918, pp. 207-210.

4. Jolly, D. W.: Field Surgery in Total War, New York, Paul B. Hoeber, Inc., 1941.

5. Heyd, C. G.: Thoraco-Abdominal Injuries: Some Technical Procedures Developed by the War, Ann. Surg. **72**:370-375, 1920.

6. Lee, W. E.: Medical Department of the U. S. Army in the World War, Washington, Government Printing Office, 1927, vol. 2, pp. 466-468.

found that only 4.6 per cent of all thoracic wounds had penetrated the abdomen in the American Expeditionary Forces of World War I.

For this study 84 cases of combined thoracoabdominal gunshot wounds were reviewed from the records of the Cook County Hospital and the Cook County Morgue. The patients in this study represent patients observed at these institutions during a four year period (1933 to 1937). Twenty-nine of these patients were treated at the Cook County Hospital; 55 were examined by the Cook County coroner's staff. Operation or postmortem examination was performed on all of the patients who died. Seventy-nine of these patients were wounded by rifle or revolver bullets in which all of the common calibers were represented. There were 5 shotgun wounds.

CLASSIFICATION

Several classifications of thoracoabdominal wounds have been described.[7] For this study it was found convenient to classify the wounds according to the clinical manifestations presented. When seen in the accident rooms of municipal hospitals during civil life or in the forward classification posts during warfare, the clinical manifestations of these wounds exhibit one of the following varieties: (1) shock (hemorrhage) syndrome; (2) thoracic (respiratory) syndrome; (3) peritoneal syndrome; (4) retroperitoneal syndrome.

Shock (Hemorrhage) Syndrome.—Massive hemorrhage is the characteristic finding in the group of patients showing the shock (hemorrhage) syndrome. In many of these patients penetration of the heart is found at autopsy (fig. 1 *A*). The patients die soon after being shot. When the aorta or the vena cava is penetrated, death also occurs rapidly. In some cases extensive laceration or pulpification of the liver, the lungs or the kidney gives rise to a rapidly fatal hemorrhage. Occasionally when a smaller vessel is severed the patient may live for several hours after being admitted to a hospital; it is only under such circumstances that any hope of successful therapy can be entertained. As has been noted in a previous paper,[8] the majority of wounds of the heart enter the lower middle or left anterior portion of the thoracic wall, and protection of this area would be effective in preventing many of such wounds.

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7. (*a*) Gordon-Taylor, G.: Chest Surgery in War: Abdominothoracic Injuries, Brit. M. J. **1**:862-864 (June 7); 898-901 (June 14) 1941. (*b*) Heyd.[5]

8. Hardt, H. G., Jr., and Seed, L.: Comparison of the Course and Direction of Fatal and Nonfatal Gunshot Wounds of the Chest, War Med. **2**:623-634 (July) 1942.

In warfare also many of the patients die before they can be evacuated to a hospital. According to Duval,[9] during warfare at least 50 per cent of the patients with penetrating wounds of the thorax die soon after injury, in the aid posts or in the ambulance units. For this reason many of the cases of massive hemorrhage do not appear among cases reported from military hospitals during war.

Thoracic (Respiratory) Syndrome.—The majority of the wounds causing the thoracic (respiratory) syndrome penetrate the lower lobe of the right lung or the right costophrenic sinus, pierce the diaphragm

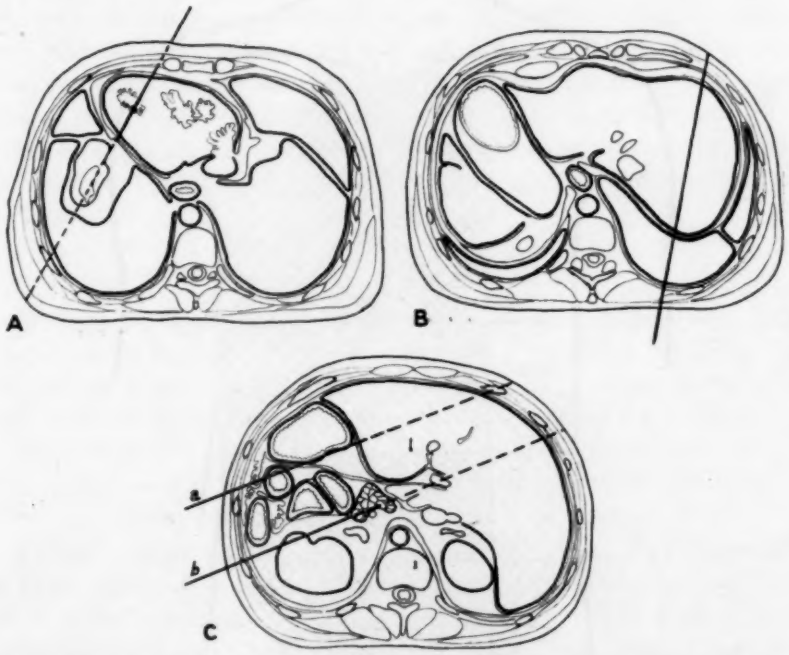

Fig. 1.—Typical courses of projectiles: *A*, causing the shock (hemorrhage) syndrome; *B*, causing thoracic (respiratory) syndrome; *C*, (*a*) causing peritoneal syndrome and (*b*) causing retroperitoneal syndrome.

and cause a tunneling or grooving lesion of the dome of the liver (fig. 1 *B*). Right-sided hemothorax is frequently present. Hepatic bleeding is usually not excessive; according to Heyd [5] hemorrhage is usually arrested by the time a laparotomy can be done. Of course, in some cases fissuring and shattering of the liver cause profuse and constant hemorrhage, but the condition is then classified under the hemorrhage syndrome. A similar clinical picture is occasionally present in

9. Duval, P.: War Wounds of the Lungs: Notes on Their Surgical Treatment at the Front, New York, William Wood & Company, 1918.

wounds of the lower part of the left lung and the spleen. The clinical course of these wounds is similar to that of penetrating wounds of the right side of the thorax. Early and uneventful recovery usually follows. Occasionally hemothorax must be treated by aspiration and replacement with air, but rarely is any operative therapy necessary. Wounds of the right hypochondrium were described as the most benign of any of the abdominal wounds by Keogh [10] (fig. 2).

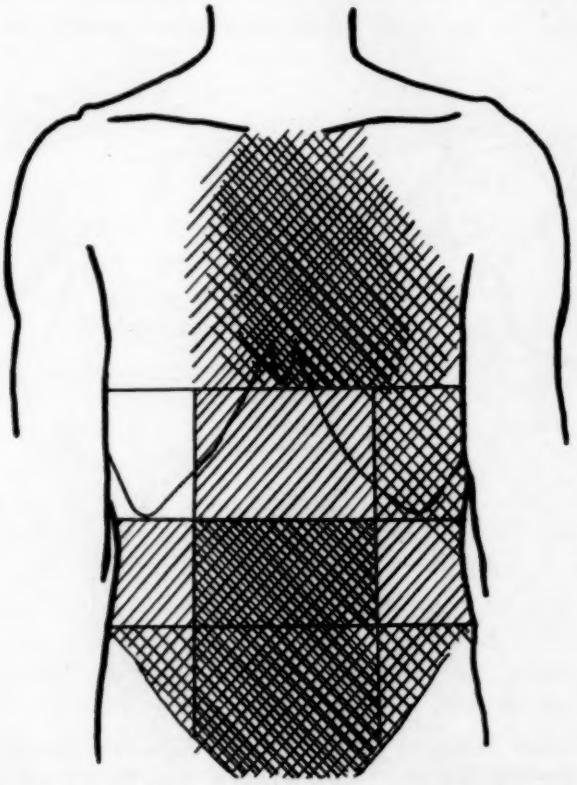

Fig. 2.—Most vulnerable areas on the anterior surface of the trunk. The darker areas indicate those in which wounds have a graver prognosis (abdominal areas after Keogh [10]).

Peritoneal Syndrome.—The peritoneal syndrome is characterized by the penetration of hollow viscera. The lower lobe of a lung or the costophrenic sinus on either side of the thorax is penetrated, and the stomach or other portions of the intestinal tract are perforated (fig. 1 *C*). In addition, there is often penetration of one or more of the solid organs

10. Keogh, A.: Medical and Surgical Therapy, New York, D. Appleton and Company, 1918, vol. 3, pp. 377-383.

in the peritoneal cavity or in the retroperitoneal region. The clinical manifestations are those of peritoneal reaction seen in perforation of any hollow viscus. Shock, abdominal tenderness, boardlike rigidity, nausea and occasional vomiting are usually present. Peristaltic sounds are absent; and distention soon appears. In these cases immediate operative repair is required; otherwise the subsequent infection becomes overwhelming.

Retroperitoneal Syndrome.—A small portion of abdominothoracic gunshot wounds present a clinical picture which has been called a retroperitoneal syndrome by Jolly.[4] The principal wound is found in the mesentery and the retroperitoneal organs (fig. 1 *C*). Pallor, weakness, feeble pulse, low blood pressure and other signs of shock are present. There is little pain and no evidence of peritoneal reaction. The shock becomes more profound, and death ensues. The exact causation of this syndrome is not clear. There is insufficient bleeding to account for the shock present. Jolly [4] expressed the opinion that the manifestations are due to damage to the splanchnic nerves.

WOUNDS OF INDIVIDUAL ORGANS

Frequency.—The frequency with which individual organs were penetrated is given in table 1. Not uncommonly a projectile penetrated the costophrenic angle; for this reason no thoracic organ was penetrated in some cases. The order of frequency varies somewhat from the rate of frequency reported by Jolly.[4] In this series there were more wounds of the kidney and fewer wounds of the spleen, so that the frequency of injury of these two organs is the reverse of that reported by Jolly.[4]

Thorax.—Heart: The heart was injured in 21 cases (25 per cent). In 17 of these there was complete penetration of at least one wall, and in 1 the myocardium was deeply lacerated. All of these patients died before they could be admitted to a hospital. In 3 cases there was simple contusion or grooving of the myocardium; the patients lived three hours, twelve hours and twenty-four hours respectively after being admitted to a hospital.

Since most of these patients die before they can be admitted to a hospital, they can rarely be treated with any hope of success. Occasionally a grooving or saucerizing lesion of the myocardium can be successfully sutured if recognized early. Elkin,[11] Bigger,[12] Griswold and Maguire [13] and others have recorded numerous instances of successful

11. Elkin, D. C.: The Diagnosis and Treatment of Cardiac Trauma, Ann. Surg. **114**:169-185 (Aug.) 1941.

12. Bigger, I. H.: The Diagnosis and Treatment of Heart Wounds, South. M. J. **33**:6-11 (Jan.) 1940.

13. Griswold, R. A., and Maguire, C. H.: Penetrating Wounds of the Heart and Pericardium, Surg., Gynec. & Obst. **74**:408-418 (Feb. 15) 1942.

repair of a penetrated heart. In the majority of cases in which treatment was successful, the wounds were caused by a knife or an ice pick. These weapons cause small wounds which penetrate only one cardiac wall and in most cases do not penetrate the pleural cavity at all. In gunshot wounds there is usually complete penetration of the heart and frequently an opening into the pleural cavity which allows massive hemorrhage to progress to the point of exsanguination. Cardiac tamponade, a common finding in knife wounds, is not frequently seen in gunshot wounds. The difference in these two types of lesions has been previously described by Bigger.[12]

Lungs: A lung may sustain a simple drill hole type of wound from a penetrating bullet, or it may be extensively lacerated and contused.

TABLE 1.—*Frequency with Which Individual Organs Were Penetrated by Gunshot Wounds*

Organ	Cases	Percentage
Thorax		
Right lung	23	27.4
Left lung	32	38.1
Heart	21	25.0
Abdomen		
Liver	59	70.3
Stomach	30	35.7
Kidney	17	20.2
Large intestine	13	15.4
Spleen	12	14.3
Pancreas	12	14.3
Small intestine	8	9.5
Adrenal gland	4	4.7
Aorta	4	4.7
Vena cava inferior	4	4.7
Gallbladder	1	1.2
Innominate vein	1	1.2

Most injuries of the latter type are caused by shell fragments. The track of the projectile is usually surrounded by a zone of parenchymal hemorrhage. In some cases profuse bleeding into the parenchyma of the lung or the bronchial tree occurs.[9] Hemothorax or hemopneumothorax is usually present. If these are minimal in extent, no active therapy will ordinarily be required; moderate or large accumulations of blood should be treated by aspiration and replacement with air. When there is extensive damage to the lung in addition to hemothorax or a large intrapleural foreign body is present, thoracotomy and repair of the lung are the treatment of choice. Pneumothorax ordinarily is desirable to secure adequate rest for the lung to promote healing. Occasionally, however, a valvelike wound may allow entrance of air but prevent its exit; constantly mounting pleural pressure or tension pneumothorax will result and may cause sufficient respiratory embarrassment to produce death unless effectively decompressed. Open pneumothorax

must be immediately closed. Operation is also indicated for wounds of the intercostal or internal mammary vessels. Large ragged wounds of the wall of the chest and compound fractures of the ribs will require débridement, cleansing and repair. Mediastinal emphysema will occasionally require an incision above the episternal notch to relieve pressure in the mediastinum and the neck. The care of penetrating wounds of the thorax has been more completely reviewed in a previous paper.[14]

Diaphragm.—Wounds of the diaphragm as seen in civilian life are small and are usually located in the sloping muscular portion of the organ. Wounds of the muscular portion of the diaphragm are considered more benign than those of the tendinous portion.[7a] In warfare also most of the wounds are small; however, some caused by large shell fragments reach sizable dimensions. The characteristic clinical finding with lesions of the diaphragm is a thoracic character of respiration with a catch, spasm or hiccup at the height of inspiration and pain referred to the scapula or the clavicle. Herniation of abdominal viscera into the thoracic cavity may occur immediately following a wound of the diaphragm. This usually occurs in those wounds in which a sizable rent is present. Diaphragmatic hernia occurring subsequent to thoracoabdominal wounds is a fairly common occurrence; it was estimated by Lee[6] to occur in approximately 10 per cent of thoracoabdominal gunshot wounds. Hernia of traumatic origin is almost invariably on the left side. Hedbloom[15] found that approximately one third of all diaphragmatic hernias in his series were of traumatic origin. Approximately half of these were due to penetrating wounds, the majority of which were caused by bullets. Many small wounds of the diaphragm heal satisfactorily spontaneously; large wounds require repair. Sauerbruch[16] and others have expressed the opinion that repair of a lacerated diaphragm is not so vital to the maintenance of respiratory equilibrium as was formerly thought. On some occasions it is technically difficult to repair a laceration of the diaphragm through an abdominal incision; consequently a transpleural approach will frequently be necessary.

Abdominal Cavity.—Liver: Because of the large size and the prominent position of the liver, it is injured more frequently by thoracoabdominal gunshot wounds than any other organ. In this series it was involved in 59 cases (70.1 per cent). Considerable variety of lesions are found among gunshot wounds of the liver. In some cases a groove

14. Hardt, H. G., Jr., and Seed, L.: Gunshot Wounds of the Chest: A Review of Two Hundred and Eighty Cases, Arch. Surg. **44**:779-788 (May) 1942.

15. Hedbloom, C. A.: Diaphragmatic Hernia, Ann. Int. Med. **8**:156-176 (Aug.) 1934.

16. Sauerbruch, F., and O'Shaughnessy, L.: Thoracic Surgery, New York, Longmans, Green & Co., 1937, pp. 346-347.

or trenchlike injury is found; in others a tunneling of the organ is present. Occasionally in association with these wounds fissures of varying size radiate from the lesion. In some cases shattering or pulpification of an entire lobe or section of the organ is found. Wounds of the last-named type are found in those patients who die soon after the injury. The explanation of these varieties of injury can be found in the type, the character and the penetrating force of the missile. The clinical findings vary with the type and the extent of the damage present. In cases of severe shattering lesions the findings are those of profuse hemorrhage; mild lesions may be symptomless. The clinical manifestations are often obscured by the presence of damage to other viscera. Jaundice appearing soon after injury is usually temporary; jaundice developing late in the course of an injury often indicates infection according to Gordon-Taylor.[7a] Secondary hemorrhage from wounds of the liver is often severe and is frequently fatal. Laparotomy is indicated for wounds involving the liver when bleeding is progressive and when a large foreign body is present in the substance of the liver. The bleeding is controlled by packing or suture.

Spleen: In this series the spleen was penetrated in 12 cases (14.3 per cent). Wounds of the spleen resemble those of the liver. They are usually grooved or trenchlike but may be shattering or pulpifying. Wounds of the pedicle frequently give rise to fatal hemorrhage. Clinical findings are similar to those in cases of wounds of the liver. Wounds of the spleen are seldom found to be the only abdominal visceral injury. With some of the less severe wounds of the organ suture may be possible but many require splenectomy. Jolly [4] was enthusiastic over the results of splenectomy observed by him in the Spanish civil war. Transthoracic splenectomy has been frequently performed with success by Gordon-Taylor.[7a]

Hollow Viscera.—The stomach, the colon or the small intestine may be penetrated in thoracoabdominal gunshot wounds. In this series the stomach was the most frequently injured, being penetrated in 30 cases (35.7 per cent). The transverse colon or the splenic or the hepatic flexure was pierced in 13 cases (15.4 per cent), while the small intestine was perforated in 8 cases (9.5 per cent).

The type of perforation of these hollow viscera depends on the course and direction and the type of penetrating missile. A bullet or shrapnel usually causes either penetration of both walls or, when penetrating at an angle or striking an edge of the organ, tearing of a single area of one wall. Wounds caused by shell fragments or shotgun discharges usually tear a large section of the organ away or completely divide it. Wounds of the greater or lesser curvatures of the stomach may involve

the large blood vessels in the mesentery, causing profound and even fatal hemorrhage. This may also occur in wounds of the mesocolon or the mesentery of the small intestines. The clinical findings are those of general peritonitis. Shock, abdominal rigidity, localized tenderness, nausea and absence of peristaltic sounds are usual. Vomiting is often present when the stomach is involved. Laparotomy is indicated when penetration of a hollow viscus is suspected. Obviously the prognosis of these wounds is better for those patients who are operated on soon after infliction of their wound. Simple suture of the perforations should be done whenever possible. This has been advocated by Bailey,[17] even when it entails considerable narrowing of the intestinal lumen. The mortality associated with suture is considerably less than that associated with resection; consequently resection should be done only in those cases in which there is no reasonable alternative.

Extraperitoneal Organs.—Pancreas: The pancreas was penetrated in 12 cases (14.3 per cent) in this series. Pancreatic lesions are rarely recognized preoperatively. Certainly many of them are fatal. This may be due to hemorrhage from the many large vessels in the vicinity; it may occur with the retroperitoneal syndrome described earlier, or extensive fat necrosis may be a contributing factor to the fatal outcome. Suppurative gangrenous pancreatitis may produce death in twenty-four hours in cases of pancreatic wounds according to Heyd.[5] It is difficult to determine whether any pancreatic lesions tend to simple regression.

Kidney: In this series the kidney was injured in 17 cases (20.2 per cent). The kidney may be contused from projectiles passing in the vicinity of the organ. This may cause hematuria (which is temporary) but few or no complications. A projectile may cause a tunnel-like perforation or bisect or pulpify the organ. The character of the wounds depends on the type and the energy of the penetrating missile. Injury to other organs is usual. The prognosis is particularly grave when the colon is perforated in addition to the kidney. Perforation of the renal pedicle or the calices is usually fatal. The diagnosis is established from the course of the wound and the presence of perirenal effusion and hematuria. Operation is indicated in the presence of large perirenal effusion, large foreign bodies and persistent bleeding. The usual surgical procedures are packing, suture and nephrectomy. Occasionally repair of a kidney through a lesion in the diaphragm is possible according to Swan.[18] Heminephrectomy is rarely indicated.

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17. Bailey, H.: Surgery of Modern Warfare, Baltimore, Williams & Wilkins Company, 1941, vol. 1, p. 209.

18. Swan, R. H. J.: Injuries of the Kidney, Brit. J. Urol. **12**:161-176 (Sept.) 1940.

Adrenal Gland: The adrenal gland was penetrated in 4 cases (4.7 per cent). There have been few if any publications in the literature discussing gunshot wounds of this organ. In none of the cases in this series could any evidence of adrenal insufficiency be found.

COMBINATIONS OF VISCERA INJURED

Although many thoracoabdominal wounds exhibit an infinite variety in the combinations of organs and structures penetrated, certain combinations of wounds occur with a greater frequency. In table 2 are listed the more common combinations of wounds observed. These correspond fairly closely with the combinations observed by Lockwood and Nixon,[19] with the exception that those observers were in hospitals during warfare and therefore failed to see many of the rapidly fatal wounds involving the heart which were seen in this series.

TABLE 2.—*Frequency with Which Combinations of Viscera Were Injured by Gunshot Wounds*

Combination of Viscera	Cases	Percentage
Lung or costophrenic sinus and liver	17	20.2
Lung, heart and liver	7	8.3
Lung or costophrenic sinus, liver and stomach	6	7.1
Lung and stomach	4	4.7
Lung, liver and kidney	4	4.7
Heart and liver	4	4.7
Lung and spleen	3	3.5

DIAGNOSIS

In many cases, in which both a wound of entrance and one of exit are present, the diagnosis is obvious and the organs penetrated can be readily ascertained. In some cases, in which only an entrance wound is present, it may be difficult to determine whether a thoracoabdominal wound has been inflicted. In these cases a knowledge of the position of the patient when the wound was received and of the general direction of the adversary may be of considerable value. This has been emphasized by Meyer and Shapiro.[20] Information on the course of the bullet can often be obtained from a careful examination of the entrance wound. It is sometimes difficult to determine whether a wound is entirely thoracic or whether the abdominal cavity has been entered. Abdominal

19. Lockwood, A. L., and Nixon, J. A.: War Surgery of the Chest, Brit. M. J. **1**:104-109 (Jan. 26) 1918.

20. Meyer, K., and Shapiro, P. F.: Treatment of Abdominal Injuries: Collective Review, Internat. Abstr. Surg. **66**:245-257, 1938; in Surg., Gynec. & Obst., May 1938.

rigidity is frequently present with wounds of the lower part of the thorax; however, it is usually unilateral, while bilateral rigidity is often found with abdominal wounds. The rigidity with thoracic wounds is usually intermittent with respiration, while with abdominal wounds the rigidity is continuous. Vomiting and gaseous eructations are not unusual with abdominal wounds and are rare with purely thoracic wounds. When it is difficult to determine whether a wound is entirely thoracic, and also generally in cases of thoracoabdominal gunshot wounds, a flat plate roentgenogram of the upper part of the abdomen and the lower part of the thorax or fluoroscopic examination is of great value. By the position of the projectile, if this can be visualized, its course can often be determined. The presence of pneumothorax or hemothorax will establish the fact that the pleural cavity has been penetrated. The finding of air under the diaphragm confirms the presence of injury of a hollow viscus. Hemopericardium can readily be detected, and hematomas, tension pneumothorax and other abnormalities are often demonstrable.

In patients admitted to the hospital with the hemorrhage syndrome the presence of severe shock makes the diagnosis obvious; occasionally it may be fairly difficult to determine whether the bleeding is in the thoracic or the abdominal cavity. In most cases, however, hemothorax or hemopericardium can easily be detected by ordinary physical examination. If these are absent, it is reasonable to assume that bleeding in the abdominal cavity is present.

In cases of thoracoabdominal wounds of the thoracic type the location of the wound and the benign character of the clinical picture (providing bleeding is not excessive) are easily recognized. The differential diagnosis between purely thoracic wounds and combined wounds will be of value in those cases in which there is some doubt concerning the possibility of perforation of a hollow viscus.

The peritoneal syndrome is characterized by the readily recognizable feature of general peritonitis in almost every instance and should cause no difficulty.

The retroperitoneal syndrome will be characterized by profound shock which is progressive. Careful search will reveal no evident profuse bleeding. Peritoneal reaction will be minimal. The diagnosis can be made from the course of the wound and the exclusion of excessive bleeding and peritonitis in the presence of shock with little pain.

PROGNOSIS

Of the 29 patients admitted to Cook County Hospital with thoracoabdominal gunshot wounds, 13 recovered (mortality of 56 per cent). Projection of their cases with those obtained from the Cook County

Morgue (in some of the latter, treatment was carried out in other hospitals) reveals that approximately one third of the patients die immediately or at least soon after injury, that one third die after having received treatment in a hospital and that one third recover. Mortality rates reported by various observers vary from the 20 per cent quoted by Saint [21] to 75 per cent in the forward areas in warfare.[5] The mortality rate will certainly vary greatly with the type of warfare, the length of time after injury and the facilities for therapy available. Wounds involving the structures in the right hypochondrium and lower right part of the thorax carry a favorable prognosis. Wounds of the lower left and lower middle portions of the anterior part of the chest will usually be rapidly fatal from penetration of the heart. Wounds of hollow abdominal viscera have a much higher mortality than wounds of solid viscera.[22] Among wounds of the hollow viscera the prognosis is better for wounds of the stomach than for intestinal wounds; for wounds of the small intestine the mortality is lower than for wounds of the colon. Penetration of both leaves of the diaphragm has a high mortality.

Lilienthal [23] expressed the opinion that wounds penetrating from abdomen to thorax have a higher mortality than those passing from thorax to abdomen. The high mortality in the hospital from abdominal wounds of this type is due mainly to uncontrollable peritonitis which persists and causes death in many cases in which skilful repairs have been made. It is hoped that the local use of sulfonamide compounds in the peritoneal cavity will aid in the control of such infection sufficiently to cause a marked lowering of this mortality.

CAUSE OF DEATH

The cases herein reported cannot yield a true cross index of thoracoabdominal gunshot wounds, since the cases from the hospital do not include the cases in which death occurred before hospitalization could be effected and the coroner's cases do not include the cases from other hospitals in which recovery took place. However, an approximation of the true proportions can be obtained by projection of the figures available here. These figures reveal that approximately one third of all patients die from profound hemorrhage before active therapy can be instituted in a hospital. Approximately one third of the patients die in spite of active therapy in the hospital, and one third recover.

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21. Saint, cited by Taylor.[2]

22. Rippy, E. L.: Management of Perforating Gunshot Wounds of the Abdomen, South. Surgeon **10**:441-450 (June) 1941. Gordon-Taylor, G.: Abdominal Injuries of Warfare, Bristol, John Wright & Sons, Ltd., 1939.

23. Lilienthal, H.: Thoracic Surgery, Philadelphia, W. B. Saunders Company, 1926, vol. 2, pp. 568-570.

In the first group hemorrhage frequently arises from the heart or other portions of the central vascular tree, but occasionally persistent bleeding from a smaller vessel is the causative factor. In the latter instance the patient often lives several hours after being admitted to the hospital before he dies. Thirty-seven patients in this series died from hemorrhage.

Infection is by far the most common cause of death in those patients who have received active therapy in the hospital. There were 21 deaths from infection in this series. Death usually occurs between the second and the fifth day in the hospital. Infection may be present in any of the body cavities penetrated, and it is interesting to note that in the majority of cases infection is present in both cavities penetrated. The

TABLE 3.—*Major Source of Bleeding in Thirty-Seven Deaths from Hemorrhage*

Source of Hemorrhage	Cases	Hours Patient Lived After Admission to the Hospital
Heart (21 cases)		
Heart penetrated	17	0
Myocardium lacerated	1	0
Myocardium contused	1	3
Saucerized ventricle	1	12
Grooved ventricle	1	24
Aorta (abdominal)	4	0, 0, 0, 5
Lung	4	0, 0, 4, 48
Kidney	3	0, 5, 6
Liver (shattered)	2	0, 6
Right innominate vein	1	0
Splenic artery (large branch)	1	19
Hematoma in the anterior mediastinum	1	6

findings of late general peritonitis and pyohemothorax are usually obvious.

Seven patients in this series died soon after operation. In cases of this kind it is unfortunately impossible to determine with certainty which of the patients will be able to withstand the additional shock of operation and which will not. It is hoped that improvements in preoperative preparation of the patient and utilization of whole blood and plasma in the operating room will aid in reducing the number of postoperative deaths. Large amounts of blood and plasma (1,000 to 2,000 cc.) may be necessary to restore the patient's blood volume in the operating room.[24]

Three patients died in deep shock six to ten hours after injury. Postmortem examination failed to reveal sufficient bleeding to explain the shock present. These patients all had severe retroperitoneal wounds,

24. Storck, A. H.: Gunshot Wounds of the Abdomen, Surg., Gynec. & Obst. **74**:425-427 (Feb., no. 2A) 1942.

and for want of a more adequate explanation of the cause of death we place their wounds in the category of retroperitoneal syndrome described by Jolly.[4] It is interesting to note that the pancreas was penetrated in each of these cases.

Two patients died from paralytic ileus. One death occurred twenty-six days after injury and the other three and a half days after the patient was wounded.

TREATMENT

Wounds of the right lower part of the thorax and the right hypochondrium frequently require no operative therapy. Right hemothorax may be treated by aspiration and air replacement if sizable. Operation is indicated only when a large foreign body is present or when there is considerable damage to the organ with continued bleeding. These indications are equally true for both the lower lobe of the right lung and the liver.

If a wound of the heart is suspected from the site of the wound and the clinical findings, immediate exploration is imperative. If early operation is done on patients who reached the hospital, the bleeding from a grooving or saucerizing lesion of the myocardium can be successfully arrested. Unfortunately most of the lesions will have penetrated the cardiac wall and the patient will fail to reach the hospital alive.

Wounds with perforation of hollow viscera require laparotomy as soon as the patient's condition warrants. It has been demonstrated accurately that the prognosis is much better for those patients on whom operation is done early. Exploration of the spleen is indicated in the presence of continued bleeding, and this holds true also for the kidney. It may be possible to examine the spleen through the pleural cavity if this cavity must be entered for other reasons. This is advocated by Jolly [4] and Gordon-Taylor.[7a] Transperitoneal exploration of the kidney is not recommended.

It may frequently be difficult to determine whether to perform an exploratory operation first on the thoracic or on the abdominal cavity. Duval [9] expressed the opinion that the pleural cavity should be operated on first: (1) if open pneumothorax is present; (2) if a large intrapleural foreign body is found, or (3) if a large amount of parenchymal damage with continued bleeding from the lung is present. Jolly [4] stated his belief that transpleural laparotomy is indicated when a large diaphragmatic perforation is present or when the course of the projectile is known to be in the upper part of the abdomen. The fact that when infection occurs both the pleural and the abdominal cavity are involved in a majority of cases should indicate that careful suture of the diaphragm should be done if at all possible.

Autotransfusion of blood in hemothorax cavities as advocated by Brown [25] should be done only in carefully selected instances of thoracoabdominal wounds, since penetration of abdominal structures may allow infection to enter the pleural cavity. The adequate use of sulfonamide compounds orally and in the thoracic as well as the peritoneal cavity in those cases in which a hollow viscus has been penetrated may be helpful in controlling the infection present. It is to be hoped that a large number of patients with wounds of types that in the past have proved fatal because of infection will be saved in the future by the use of sulfonamide compounds.

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25. Brown, A. L., and Debenham, M. W.: Autotransfusion: Use of Blood from Hemothorax, J. A. M. A. **96**:1223-1225 (April 11) 1931.

PROGRESS IN ORTHOPEDIC SURGERY FOR 1941

A REVIEW PREPARED BY AN EDITORIAL BOARD OF THE AMERICAN ACADEMY OF ORTHOPAEDIC SURGEONS

(Concluded from Page 1021)

XVI. CONDITIONS INVOLVING THE FOOT AND ANKLE

Foot Imbalance.—Schwartz and Heath [605] conclude from clinical observation and laboratory investigation of the foot in action: (1) that perfect alinement between the foot and the leg can be maintained without muscle support; (2) that unusual development of the intrinsic and extrinsic muscles of the foot and the leg does not prevent pronation in stance and locomotion; (3) that the presence or the absence of pronation can be explained on the basis of functional characteristics of the os calcis and the cuboid bone and their physical relation to the astragalus and the tibia. (A neutral or varus position of the os calcis does not permit pronation of the foot.)

These conclusions are in harmony with the observations of Morton [606] and others that foot balance depends on two factors: (1) structural stability, by which is meant the arrangement of the bones and the ligaments of the foot which enables it to provide a rigid base of support for superimposed body weight; (2) postural stability, by which is meant that quality by which the center of transmitted weight is constantly maintained in a balanced position over the astragalus with each shift of the body weight.

According to these authors both true structural and true postural stability depend on the maintenance of a parallel between the axis of weight bearing of the os calcis and the tibia. They therefore conclude that muscle exercises are contraindicated in the treatment of pronation and that treatment is limited to means which will maintain a neutral or varus position of the os calcis. [ED. NOTE: While we agree entirely with the basic conclusions of Schwartz and Heath, we feel that the long extrinsic muscles of the foot across the subtalar joint do play a definite role in maintaining the leg in a functionally vertical position over the os calcis with each shift of the body weight and that the desir-

605. Schwartz, R. P., and Heath, A. L.: Foot Function Correlated with Anatomic, Clinical and Laboratory Data, New York State J. Med. **41**:447-451 (March 1) 1941.

606. Morton, D. J.: Functional Disorders of Foot and Their Treatment, Arch. Phys. Therapy **22**:651-655 (Nov.) 1941.

ability of establishing adequate strength and tone in the long muscles cannot be ignored in the treatment of pronated feet.]

The authors emphasize also a fundamental fact when they point out that the distorting influence of pronation on the cartilaginous skeleton of the child's foot results in changes in shape and structure of the bones of the foot, particularly the os calcis, which are so predetermined as to express the characteristics of pronation in adult life. The correction of faulty foot posture in childhood will eliminate a large part of the foot disorders of adult life. R. L. Jones,[607] an anatomist, using an ingenious apparatus for measuring the mechanics of the foot, also concludes that the plantar ligaments and the short plantar muscles bear the greater part of the burden of supporting the longitudinal arch of the foot and that the long leg muscles do about 15 to 20 per cent of the work. He does concede, however, that the long muscles have a definite role in maintaining the leg in a balanced position over the foot and in this way influence the distribution of weight. An unequal distribution of weight over the foot is one of the fundamental causes of the breaking down of the structural stability, and Jones's contention that the long muscles of the foot (leg) are completely unimportant in supporting the longitudinal arch seems to fail of proof. On the other hand, a preponderance of evidence based on clinical experience does support his claim that a depressed longitudinal arch cannot be elevated by exercises of muscles alone. Finally, Jones makes the flat statement that commercial arch supports are of little value as elevators of the arches of the foot. [ED. NOTE: This claim is well founded, since such supports seldom meet all of the requirements in a truly imbalanced foot; it is not true, however, of properly designed and properly fitted supports made to meet the needs of the individual patient.] Wiles[608] has written an interesting article covering much ground with regard to functional disorders of the foot and their causes. [ED. NOTE: This is an interesting and practical article, which will repay a careful perusal. It should be read in the original.] Creer[609] gives an interesting account of the treatment of disabling foot conditions in England, particularly in the light of the fact that the chiropodist is recognized there as an adjunct to the physician. [ED. NOTE: While such an arrangement is sound when it can be properly controlled, as

607. Jones, R. L.: Human Foot: Experimental Study of Its Mechanics, and Role of Its Muscles and Ligaments in Support of Arch, Am. J. Anat. **68**: 1-39 (Jan.) 1941.

608. Wiles, P.: Some Common Causes of Painful Feet, Practitioner **146**: 389-394 (June) 1941.

609. Creer, W. S.: Foot Disabilities and Foot Clinics, J. Roy. Inst. Pub. Health & Hyg. **4**:118-130 (May) 1941.

it apparently is in England, it is definitely questionable that it would work out in this country, where cults and isms so rapidly become important and so readily overstep the bounds of their capacity.] Creer properly emphasizes in his article the importance from an economic point of view of properly caring for disabling foot conditions.

Hollow Foot.—Huber [610] calls attention to the insufficiency of the hollow or high-arched foot in industrial workers and the possibility that trauma (of occupation) may cause hollow foot. [ED. NOTE: One of us (R.L.D.) has long felt that the high-arched foot as a form of foot imbalance has been too generally neglected and suggests that this article is well worth the consideration of those interested in conditions affecting the foot. Some of the methods of treatment which Huber advises cannot be accepted unqualifiedly, e. g., tenotomy, for it is doubted that hollow foot can ever be corrected by such a procedure. Proper attention to the shoe is far more likely to give relief, and if operation is considered necessary, the operative procedure should be directed toward correcting the faulty alinement of the bones of the foot. Usually a midtarsal arthrodesis is necessary to accomplish this result.]

Conditions Involving the Foot in Relation to Military Service.—Helfet [611] recommends dividing into two groups the foot strain found in soldiers: (1) conditions affecting a flexible foot and (2) those affecting a rigid foot. He believes that distinguishing between the rigid and the flexible types of foot is definitely important. Treatment is based on the type of foot and correction to be secured by exercises, relief of pressure on bony points and satisfactory fitting of army shoes. Experience indicates that proper fitting of the shoe or the boot is the most important factor in maintaining foot efficiency in military service. Geckeler [612] thoroughly discusses the examination of the feet of selectees for military service and gives in detail the standards used in determining whether the selectee is to be accepted or rejected. The various types of conditions affecting the foot encountered in such examining work are discussed, and treatment is suggested. A similar article by Todd [613] contains a great deal of useful information on the examination and the care of the feet of those in the armed services. Practically all of the important points he makes and the methods of treatment

610. Huber, H. H.: Hollow Foot in Industry, Wisconsin M. J. **40**:30 (Jan.) 1941.

611. Helfet, A. J.: Treatment of Soldier's Foot, J. Roy. Army M. Corps **76**:282-285 (May) 1941.

612. Geckeler, E. O.: Disorders of Foot in Relation to Military Service, M. Clin. North America **25**:1843-1857 (Nov.) 1941.

613. Todd, A. H.: Treatment of Flat Feet in Recruits, M. Press **206**:130-136 (Aug. 13) 1941.

he advises are sound. It deals in a thorough way with the problems commonly encountered and gives many helpful suggestions. Both these articles should be of great interest and value to those who examine troops or who are in active service with troops. Kreglinger [614] ascribes the ability of the German troops to march 50 to 60 kilometers per day to the type of shoes they wear. This shoe is one with a thin sole, a broad toe and a long broad low heel. He claims that proper mobility of the foot is permitted in a shoe of this type, thus relieving strain.

Hallux Valgus.—Stracker [615] outlines the pathologic changes involved in hallux valgus and discusses the theories of its pathogenesis. He believes that the harmful effects of shoes are overemphasized and that the basic cause of the condition is a pathologic relation between the structure and the function of the foot. There may be other factors, such as polyarthritis or synovial changes in the joint of the great toe. He considers that treatment may be conservative or operative in accordance with the symptoms and their causes. Conservative measures include proper fitting of shoes and stockings, the use of various types of bandages and splints for straightening the great toe and exercises tending to strengthen the adductor muscles. He recommends protecting the painful bunion by various protective covers and ointments. With regard to operative treatment he reviews the technic and the results of the more common operations and stresses the indications for each type of operation. He advises against osteotomy unless prolonged rest in bed is possible and recommends operations involving the soft tissues only (capsules, ligaments, and tendons). [ED. NOTE: The various agents which Stracker has recommended for the correction of hallux valgus, such as bandages, splints and exercises, have in the experience of one of us (R.L.D.) met with practically no success in the correction of the condition. When hallux valgus or bunion is symptom producing, a properly planned operation will give a much more satisfactory result and relieve the patient of the constant necessity of applying bandages and protectors to the uncomfortable foot. It has not been the experience of this editor that operations on the soft parts alone are successful. Removal of the exostosis and correction of the valgus deformity are necessary for a successful outcome.] Veyrassat and Berner [616] report the results of a follow-up study of 19 patients operated on by Hüter's technic. Their observations do not

614. Kreglinger, G.: Footwear and Marching Capacity, Med. Klin. **36**: 1163-1164 (Oct. 18) 1940.

615. Stracker, O.: Hallux Valgus, Wien. klin. Wchnschr. **53**:885-889 (Nov.1) 1940.

616. Veyrassat, J., and Berner, A.: Hallux Valgus, Late Results of Höter Operation, Schweiz. med. Wchnschr. **71**:587-590 (May 3) 1941.

justify the usual objections to this operation, namely, that it destroys the normal anterior point of support of the foot and creates postoperative flatfoot. In cases in which flatfoot was present, the authors attribute it to hallux valgus and not to the operation. They caution against too extensive resection of the head of the first metatarsal bone. Satisfactory results are obtained by resection of only 8 to 10 mm. They believe that a marked advantage of Hüter's operation as compared with other types is the rapidity of convalescence, most patients being able to resume normal activity within one month. [ED. NOTE: Hüter's procedure does give satisfactory results, but it does carry a real possibility of destroying proper foot balance. The same result can be obtained by the Keller operation without the risk of later disturbance of foot balance.] Hansen [617] reports a follow-up study of patients with hallux valgus on whom Hüter, Mayo and Hohmann operations were performed. This series covers patients one to fifteen years after operation. It was found that 6 patients on whom the Hüter operation (resection of the head of the first metatarsal) was done had satisfactory position of the great toe in all cases, but the mobility in the joint was poor, 2 patients showing complete ankylosis. Hansen concludes that the Hüter operation is best suited for patients who before operation have articular changes and flatfoot. In 8 cases in which the Mayo operation was done there was improvement after operation, but in none was the result completely satisfactory, the mobility of the joints being bad in the majority of the cases. Hansen feels that the best results were obtained from the Hohmann operation. All 16 patients operated on walked with natural locomotion, while the mobility of the joint was limited in only 2 cases. Mayr [618] believes that most of the patients with severe hallux valgus rejected from military service may be restored to normal function by means of the Hohmann operation. This operation consists of a wedge-shaped osteotomy close to the head of the first metatarsal bone with simultaneous shortening of the bone from 1 to 2 cm. Mayr stresses the point that the proximal phalangeal joints of the large and small toes should be on the same level after operation. He believes that after osteotomy the metatarsal head should be pushed as far as possible in a lateral and plantar direction and that the abductor hallucis should be displaced laterally. He uses a plaster cast after the operation to correct the spread foot and requires four weeks' rest in bed. Mayr bases his con-

617. Hansen, N. S.: After-Examination of Patients with Hallux Valgus Operated on According to Hüter, Mayo and Hohmann Methods, Nord. med. (Hospitalstid.) **9**:135-138 (Jan. 11) 1941.

618. Mayr, O.: Surgical Therapy of Hallux Valgus in Wartime, Arch. f. orthop. u. Unfall-Chir. **40**:485-491, 1940.

clusions on 20 cases in civilian life in which he obtained excellent results from both a functional and a cosmetic point of view. He stresses the point that this operation is indicated only for young persons with no arthritic changes in the first metatarsophalangeal joint. [ED. NOTE: One of us (R.L.D.) unquestionably agrees with Mayr that this operation should be reserved for young patients without arthritis. This editor would go farther than this and state that when such changes are present this operation is definitely contraindicated.] Anderson [619] presents a series of cases of hallux valgus which he adds to a previous series reported from the orthopedic department of the Massachusetts General Hospital, Boston. The operation employed in this series was the Keller operation; it gave satisfactory results. [ED. NOTE: It should be appreciated that while the Keller operation is perhaps the most generally satisfactory type of operation for the correction of hallux valgus it does not correct the metatarsus varus primus which is so frequently an underlying cause of the condition; unless this metatarsus varus primus is corrected, a relapse or an unsatisfactory outcome may result. The Lapidus operation is the only described procedure which effectively overcomes metatarsus varus primus.] E. A. Jones [620] reports a series of cases of hallux valgus treated by the McBride operation and points out certain advantages of the operation. The chief advantages, he feels, are that the joint is not attacked, that there is no fracture made of the metatarsal head and that it is designed to prevent and correct muscle imbalance.

Batts [621] describes an ingenious method of holding the great toe in the corrected position after bunionectomy or the correction of hallux valgus. A rubber glove is cut out; the thumb portion and the thumb side of the wrist and the entirety of the wrist are used, the fingers being cut off. The wrist portion is then placed around the ankle and the thumb portion is placed around the distal end of the great toe. The elasticity of the rubber glove tends to hold the great toe in a varus position. [ED. NOTE: One of us (R.L.D.) has used this device and has found it satisfactory.]

Hallux Varus.—McElvenny [622] states that the condition of hallux varus is an unusual deformity and is usually unilateral. The first metatarsal bone is shorter and broader than normal and projects medially

619. Anderson, R. L.: Hallux Valgus, West Virginia M. J. **37**:289-292 (July) 1941.

620. Jones, E. A.: McBride Operation for Hallux Valgus, Tr. New England S. Soc. **23**:57-60, 1941.

621. Batts, M., Jr.: Simple Corrective Device for Hallux Valgus, J. Bone & Joint Surg. **23**:183 (Jan.) 1941.

622. McElvenny, R. T.: Hallux Varus, Quart. Bull. Northwestern Univ. M. School **15**:277-280, 1941.

so that it lies in a line with the rear portion of the foot. The thickened first metatarsal bone may in some ways be considered a fusion of two metatarsal bones. The author describes an operation for the correction of hallux varus which is complicated; the description should be read in the original, since the accompanying illustrations are necessary to make the technic clear.

Measurements of Foot Movements. — Manter,[623] an anatomist, describes an ingenious apparatus for measuring movements in the subtalar and transverse tarsal joints. The article is largely technical and should be read in the original; the chief clinical interest lies in the evidence it provides to support elevation of the inner side of the heel and the outer margin of the forepart of the shoe for the correction of pronation. Thomsen [624] and Ott [625] describe the use of an apparatus designed by Thomsen for measuring the anterior part of the foot, its passive spreading when supporting weight and its active narrowing by muscular contraction. The subject discussed is only of academic interest and has little practical application in the treatment of conditions affecting the foot.

Conditions Involving the Foot in Children.—Boorstein [626] gives statistics on the prevalence of flatfoot in the newborn. He strongly urges a careful appraisal of foot structure in the newborn child and a careful search for abnormalities on the ground that much foot imbalance is attributable to mild abnormalities in structure present at birth. He urges early treatment by strapping and exercises. While careful inspection of the infant's foot should unquestionably be part of the complete examination that is given the newborn, and while any detectable abnormality demands corrective measures, the diagnosis of flatfoot in the newborn hardly seems possible, since true development of the arch of the foot does not begin until weight bearing is started. Sofield [627] has written a satisfactory article on foot hygiene for children with normal feet. Proper shoeing of the normal foot of a child and the importance of early correction by a qualified physician of all departures from normal are properly emphasized. [ED. NOTE: The article might well be read by all those whose practice has to do with the growing child.]

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623. Manter, J. T.: Movements of Subtalar and Transverse Tarsal Joints, Anat. Rec. **80**:397-410 (Aug. 25) 1941.

624. Thomsen, W.: New Apparatus for Measurement of Passive and Active Changes in Breadth of Foot, Ztschr. f. Orthop. **71**:182-189, 1940.

625. Ott, L.: Passive and Active Variations in Anterior Part of Foot, Arch. f. orthop. u. Unfall-Chir. **40**:446-457, 1940.

626. Boorstein, S. W.: Flat Feet at Birth, Hygeia **19**:372-374 (May) 1941.

627. Sofield, H. A.: Care of Feet of Normal Children, Illinois M. J. **79**: 253-256 (March) 1941.

Exostosis on the Os Calcis.—Frohlich [628] calls attention to the formation of an exostosis on the upper posterior pole of the os calcis (Haglund heel), which is often confused with achilles bursitis. Simple removal of the exostosis is all that is necessary for cure. Thomsen [629] discusses the same subject and arrives at the same conclusion, namely, that simple removal is all that is necessary. He has discontinued the complicated operative procedure advised by himself in the past.

Accessory Bones of the Foot.—In several articles on supernumerary bones of the foot, differences of opinion are expressed. Licht [630] and Delano [631] discuss bipartite os naviculare pedis and os intermetatarseum (a small accessory bone lying between the bases of the metatarsal bones) and come to the conclusion that such supernumerary bones are rarely of any clinical importance. Gottlieb [632] and Perez [633] believe that the accessory bones frequently cause irritation and inflammatory conditions and are of definite clinical importance. There can be no doubt that an accessory scaphoid bone because it interferes with the attachment of the tendon of the tibialis posticus muscle does allow pronation of the foot and that frequently irritation over the accessory scaphoid bone occurs because of pressure against the shoe. Careful shoeing of the foot and correction of pronation will relieve any irritation present, but the accompanying pronation or flatfoot can be completely corrected only by appropriate operative measures, such as Kidner's operation.

Diseases and Injuries of the Tendo Achillis.—Williams [634] reports 43 cases of tenosynovitis of the tendo achillis and emphasizes the diagnostic importance of pain in the heel and along the tendon. The author considers of diagnostic importance pain in the heel and along the Achilles tendon, swelling over the lower end of the tendon sheath and crepitus over the tendon on movement. These symptoms differentiate the condition from achilles bursitis, since in cases of the latter condi-

628. Frohlich, E.: Abnormalities of the Calcaneum, the Haglund Heel, Röntgenpraxis **12**:221-224 (June) 1940.

629. Thomsen, W.: Impracticality of Suggested Surgical Therapy of Haglund Heel, Ztschr. f. Orthop. **71**:256-260, 1940.

630. Licht, E. deF.: Bipartite Os Naviculare Pedis, Acta radiol. **22**:377-382, 1941.

631. Delano, P. J.: Os Intermetatarseum: Unusual Variant, Radiology **37**: 102-103 (July) 1941.

632. Gottlieb, A.: Clinical Significance of Accessory Bones of Foot, West. J. Surg. **49**:452-453 (Aug.) 1941.

633. Perez, I. P.: Osteochondrosis of Supernumerary Scaphoid Bone: Cases, Cir. ortop. y traumatol., Habana **8**:90-96 (July-Sept.) 1940.

634. Williams, A. A.: Tenosynovitis of Tendo Achillis, Brit. M. J. **2**:377-378 (Sept. 13) 1941.

tion, the pain is localized over the insertion of the tendon, is not accompanied by crepitus and usually comes on after violent exertion. The most important causative factor of tenosynovitis of the achilles tendon, according to Williams, is wearing shoes or boots which constrict the forepart of the foot and raise a ridge at the back over the heel which causes pressure on the tendo achillis. Williams believes that boots and extended marching do not cause tenosynovitis; this is a point worthy of notice. He advocates the wearing of loose-fitting shoes and boots for those doing a great deal of marching and the treating of the condition once established by the injection of procaine hydrochloride into the sheath of the tendon. Davis [635] reports a number of cases of achilles bursitis coming on after prolonged marching. He has had success in treating this condition by using two cylinders of soft material 2 by 4 by 4 inches (5 by 10.2 by 10.2 cm.). A cylinder is placed on each side of the irritated area and strapped into place with adhesive tape.

Schnaberth [636] reports complete avulsion of the tendo achillis as a frequent accident in people over 30 years of age who take part in sports and who are unaccustomed to sport activities. He remarks on the wide retraction of the ends of the ruptured tendon, which he advocates suturing with silk rather than with fascia, after liberal resection of the splintered tendon fibers and cicatricial tissue if present. The after-treatment consists in holding the foot in the equinus position in plaster with the knee flexed. [ED. NOTE: One of us (R.L.D.) feels after a fairly wide experience that fascia lata is preferable to silk as a suture material, for while at times there may be considerable reaction following the use of fascia lata, the end results have been uniformly successful. When fascia is used, the foot does not have to be held in an equinus position; this obviates long and arduous physical therapy to correct, and motion may be instituted much earlier.] Silfverskiold [637] reports 4 cases of acute and 3 of chronic subcutaneous rupture of the achilles tendon. In all cases he repairs the rupture by a flap 4 by 10 cm., from the posterior layer of the tendo achillis; this is turned down and rotated on the distal pedicle so that the smooth outer surface remains posterior. The flap is sutured along the side and to the attachment of the distal segment of the tendon. [ED. NOTE: Here again the use of fascia seems simpler and more effective, considering

635. Davis, H. R. L.: Ambulatory Treatment for Acute Retrocalcaneobursitis, Canad. M. A. J. **45**:77 (July) 1941.

636. Schnaberth, K.: Complete Avulsion of Achilles Tendon as Present Frequent Sports Injury: Surgical Therapy, Arch. f. orthop. u. Unfall-Chir. **40**:594-597, 1940.

637. Silfverskiold, N.: Subcutaneous Total Rupture of Achilles Tendon and Its Treatment, Acta chir. Scandinav. **84**:393-413, 1941.

the shredding which occurs so frequently in the proximal part of the tendon from which a flap is taken.]

Marottoli [638] reviews previously reported cases and adds 2 new cases of ossification of the tendo achillis following injury. The ossification may be a single large center or two or more nuclei of varying sizes, usually independent of each other. The calcareous material is usually closely adherent to the tendon fibers and is excised with difficulty. The author recommends doing nothing unless the condition is causing symptoms, and then the ossification should be excised.

Osteochronditis of the Ankle Joint.—Mensor and Melody [639] point out that trauma to an ankle joint may result in breaking loose a fragment of joint cartilage which becomes a loose body. The size of such a loose body may be small enough to prevent its visualization in the ordinary roentgenogram. Taking a number of different exposures or using tomography to visualize such fragments is recommended if chronic pain and discomfort in an ankle following a sprain are complained of and do not respond to ordinary conservative treatment. One case is reported in which the result following operation was satisfactory. This is an interesting and practical observation.

Niederwieser and Grauer [640] believe that osteochondritis is not due to asceptic necrosis (osteochondritis dissecans) but to trauma, either to a single major injury or to repeated slight injuries. They report a case of osteochronditis of the ankle following reposition of a clubfoot in a child 3½ years old. They believe that spontaneous resorption of such loose bodies occurs frequently. [Ed. Note: This has not been the experience of one of us (R.L.D.); removal is usually necessary.]

Roentgen Studies of the Ankle Joint.—Wolff [641] reports the result in a study of 26 ankles in which contrast mediums were used. He considers that arthrography gives valuable information concerning lesions about the ankle joint in that it shows abnormalities in the joints, the tendon sheaths and even the tibiofibular syndesmosis which are not visible in the ordinary roentgen examination. Hansson [642] also believes

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638. Marottoli, O. R.: Ossification in Achilles Tendon Following Injury: Cases, An. de cir. **7**:83-89 (March-June) 1941.

639. Mensor, M. C., and Melody, G. F.: Osteochondritis Dissecans of Ankle Joint: Use of Tomography as Diagnostic Aid, J. Bone & Joint Surg. **23**:903-909 (Oct.) 1941.

640. Niederwieser, V., and Grauer, J.: Loose Bodies in Ankle, Traumatic Osteochondrolysis, Unusual Localization in Ankle Following Redressement for Congenital Club Foot, Spontaneous Healing, Röntgenpraxis **12**:152-156 (April) 1940.

641. Wolff, A.: Arthrography of Ankle Joint, Nord. med. (Norsk mag. f. lægevidensk.) **8**:2449-2455 (Dec. 14) 1940.

642. Hansson, C. J.: Arthrographic Studies on Ankle Joint, Acta radiol. **22**:281-287, 1941.

in the value of arthrography. He uses 3 to 6 cc. of 35 per cent solution of diodrast injected into the ankle joint after preliminary anesthesia has been induced with procaine hydrochloride. Hansson is particularly impressed with the information about the condition of the tibiofibular syndesmosis which can be obtained with this method.

Santora [643] gives a position for taking roentgenograms of the ankle joint which, according to the author, gives a much clearer view of the bones of the foot than the one ordinarily used. The patient is placed in a sitting position with the plantar surface of the foot resting on the film holder; this in turn is resting on a block angulated to 23 degrees, the heel being at the lower end and the toes at the upper end of the incline. The x-ray tube is tilted at 10 degrees and turned toward the ankle joint. According to Santora the central rays pass through the talotibial joint and demonstrate fractures of the tibia and the fibula which may be missed by the ordinary technic. The ankle joint is a complicated and important joint, and too much care cannot be exercised in getting adequate roentgenograms when injury to the joint is suspected.

The Moreaus [644] describe a method of roentgen examination for talipes varus and talipes valgus. The roentgenograms are taken with the patient standing facing a portable roentgen apparatus. The feet are perfectly parallel with their internal edges about 5 cm. apart. The centers of the heel and of the forepart of the foot are in line with the normal roentgen ray. The focus is fixed at a distance of 70 cm. and 12 cm. below the horizontal plane of the foot support. The roentgenogram shows the lower portion of the calcaneum, the tibiotarsal joint and the lower portions of the tibia and the os peroneum. Both feet appear in the same film. The authors have established landmarks by which to fix numerically the normal and pathologic angular views, thereby permitting recognition of deformity.

March Fractures.—Wilhelm [645] reports 3 cases of spontaneous fracture in soldiers in 2 of which the metatarsals were involved and in 1 on which the pelvis was affected. His theory is that such accidents are caused by the constant vibration set up during marching. He points out that the patients were of the asthenic constitutional type, unaccustomed to physical exertion. He advises physical training for all young

643. Santora, P. J.: Anteroposterior View of Ankle Joint and Foot, Am. J. Roentgenol. **45**:127-128 (Jan.) 1941.

644. Moreau, J. E., and Moreau, M. H.: Talipes Valgus and Talipes Varus: A Roentgen Study, Rev. argent. de reumatol. **6**:48-53 (May) 1941.

645. Wilhelm: "Gradual" Fractures (March Fractures): Based on Recent Observations on Soldiers, Deutsche Ztschr. f. Chir. **254**:11-19, 1940.

men with special emphasis on exercises tending to strengthen the muscles and the ligaments of the foot and a diet rich in vitamins. Moore and Bracher [646] have observed march fractures in seasoned soldiers in good health and ascribe the fracture to unusual strain on a weak second, third or fourth metatarsal bone. Unequal distribution of weight on the metatarsal bones because of faulty foot balance seems to be the most logical explanation of march fracture.

Injuries to the Foot and the Ankle.—Childress [647] has written an impressive article on subfascial hemorrhage or hematoma complicating crushing injuries of the foot. The conclusions are interesting and are as follows: 1. Subfascial hemorrhage of the dorsum of the foot frequently complicates metatarsal fractures and soft tissue hemorrhage caused by crushing trauma. 2. The cruciate ligament of the foot may act as a constricting band in subfascial swelling; the condition was produced in 8 feet from cadavers into which dye solution was injected. 3. Immediate multiple incisions to release and remove subfascial hematoma is the treatment indicated in cases in which this is severe. 4. Release by transverse section of the cruciate ligament and the transverse ligament of the foot and the ankle should be considered in cases in which there are persistent circulatory blocks. 5. Delayed or inadequate treatment results in congealed foot or in the necrosis of the soft part of the dorsal part and the forepart of the foot and the toes. [ED. NOTE: A similar condition has been noted in the hand by one of us (R.L.D.) following multiple fractures due to crushing violence.]

Gill and Abbott [648] call attention to the late results which follow fracture or separation of the medial malleolus in children. This injury may lead to premature cessation of growth in the medial portion of the distal epiphysial plate at the lower end of the tibia with resulting varus deformity of the foot and the ankle as time goes on. The authors advise careful immobilization in cases in which the condition is fresh, fusion of the distal tibial epiphysis in cases in which the condition is developing and correction of the deformity by low oblique osteotomy passing through the area of deformity or wedge osteotomy in old cases with established deformity. The possibility of interference with the distal epiphysis of the tibia with later bone deformity should be constantly borne in mind when dealing with such fractures in chil-

646. Moore, P. F., and Bracher, A. N.: March Fracture: Report of Three Cases, War Med. **1**:50-54 (Jan.) 1941.

647. Childress, H. M.: Subfascial Hematoma as Complication of Crushing Injuries to Foot, J. Bone & Joint Surg. **23**:251-255 (April) 1941.

648. Gill, G. G., and Abbott, L. C.: Varus Deformity of Ankle Following Injury to Distal Epiphysial Cartilage of Tibia in Growing Children, Surg., Gynec. & Obst. **72**:659-666 (March) 1941.

dren, and the parents should be informed at the outset of the possibility of later deformity developing for this reason.

Impink [649] discusses the importance of immediate reduction of all fractures of the tarsus and the metatarsus, since all of the bones of this region are weight bearing and failure to secure satisfactory position of fractures involving any of them may lead to serious disability. Impink prefers an unpadded plaster dressing for immobilization and the use of a walking iron incorporated in the plaster for all fractures except those of the os calcis; the weight bearing allowed by the walking iron is a stimulant to circulation. He advocates the application of an elastic bandage or an Unna's paste boot for swelling following the removal of the plaster. [ED. NOTE: While the use of an elastic bandage and the application of Unna's paste boot may be helpful when there is marked continuous swelling following the removal of plaster; as a rule, properly managed physical therapy rapidly brings about a return to normal, particularly if weight bearing has been permitted in plaster.]

Subungual Glomus.—Milch [650] makes the interesting observation that subungual glomus tumors cause a pressure atrophy on the dorsal surface of the terminal phalanx. This is due not to the pressure of the tumor itself but rather to the pulsation of the vascular portion of the tumor. Following removal of the tumor, the postoperative roentgenogram showed almost complete disappearance of the lacunas previously noted. In other words, the bone returned to normal. A series of cases is reported.

Relaxation of the Tendo Achillis in Fracture of the Leg.—Bustani [651] suggests relaxing the pull of the tendo achillis when setting fractures of the bones of the leg by infiltrating the muscles of the calf with a local anesthetic. He himself uses procaine hydrochloride. He states that he has had excellent results in a few cases. [ED. NOTE: This method of relaxing the tendo achillis has been used by Phelps for relaxing the contracted heel tendon in cases of spastic paralysis for diagnostic purposes, and it does give satisfactory relaxation. However, reduction of fractures of the bones of the leg requires general or intravenous anesthesia. Such anesthesia gives complete relaxation of the muscles of the calf, making unnecessary the additional local measures described by Bustani. If general or intravenous anesthesia is contraindicated or unobtainable, the method suggested by Bustani seems to have definite merit.]

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649. Impink, R. R.: Fractures of Foot, S. Clin. North America **20**:1815-1837 (Dec.) 1940.

650. Milch, H.: Pressure Atrophy of Terminal Phalanx Due to Subungual Glomus, Bull. Hosp. Joint Dis. **2**:128-132 (July) 1941.

651. Bustani, M.: Anesthesia of Achilles Tendon in Fractures of the Leg, Publ. méd., São Paulo **12**:41-46 (Jan.-Feb.) 1941.

XVII. CONDITIONS INVOLVING THE SHOULDER, NECK AND JAW

Lesions Due to Injury and Disease of Bursas and Tendons About the Shoulder Joint.—In a fairly complete outline of diseases of the shoulder Steindler [652] divides them into: (1) lesions of the bursa; (2) injuries to tendons and muscles overlying the bursa, and (3) other lesions, e. g., tendon rupture and brachial neuritis, which simulate bursitis. Differential diagnosis and treatment are discussed. In a similar type of paper Wilson [653] analyzes 168 cases of painful shoulder; 89 of these were lesions of the subacromial bursa; 27, lesions of the shoulder joint; 16, lesions of the bones; 10, lesions of the acromioclavicular joint, and 5, lesions of the biceps tendon. He believes that periarticular adhesions account for more cases of painful shoulder than calcareous deposits.

Wood [654] lists various systemic diseases, particularly those which involve the lung, which can produce pain in the region of the shoulder. The differential diagnosis is not always easy, but usually local tenderness and muscle spasm are absent in these systemic diseases.

An extensive study of calcium deposits about the shoulder joint has been made by B. M. Bosworth.[655] Six thousand and sixty-one persons, mostly normal people, were studied by fluoroscopic examination. One hundred and sixty-five, or 2.7 per cent, had calcium deposits in sufficient amount to show by fluoroscope; 70 of these persons had pain and discomfort in the shoulder at some time. Illness and infection played no part in the formation or regression of deposits. Trauma alone did not cause deposits. Such deposits might form in two months but usually required a longer time. Small deposits often disappeared without symptoms, but larger ones always caused symptoms. Large deposits were best treated by incision. D. M. Bosworth [656] describes a method of radical exploration of the shoulder which is not new, viz., a division of the deltoid fibers close to their acromial attachment. Fusion of the shoulder joint is advised when there is complete avulsion of the tendinous cuff. The technic of fluoroscopy of the shoulder and the method of

652. Steindler, A.: Lesions About the Shoulder Joint, Northwest Med. **40**: 3-7 (Jan.) 1941.

653. Wilson, P. D.: The Painful Shoulder, Brit. M. J. **2**:1261-1265 (Dec. 30) 1939.

654. Wood, O. T.: Clinical Significance and Differential Diagnosis of Shoulder Pain: Clinic of Eight Cases, Internat. Clin. **1**:18-24 (March) 1941.

655. Bosworth, B. M.: Calcium Deposits in Shoulder and Subacromial Bursitis: Survey of 12,122 Shoulders, J. A. M. A. **116**:2477-2482 (May 31) 1941.

656. Bosworth, D. M.: Supraspinatus Syndrome: Symptomatology, Pathology and Repair, J. A. M. A. **117**:422-428 (Aug. 9) 1941.

taking small localized roentgenograms of the calcium deposit are further described by B. M. Bosworth.[657]

Cleaves [658] describes a new film holder for roentgen examination of the shoulder. The film is placed about a bakelite tube covered with lead foil, 1⅞ inches (4.8 cm.) in diameter. This is placed in a second tube 2 inches (5 cm.) in diameter. The tube is then placed as high as possible in the axilla. The x-ray tube is centered about the shoulder. Good views are obtained of the humeral head and the acromioclavicular joint.

A discussion of inflammation in all bursas and ganglions including those about the shoulder is given by Cherry and Ghormley.[659] Excision is advised for most of them. Stumpfegger [660] claims to obtain relief of disability of the subdeltoid bursa with a protein extract from various organs of the body (Clauden) injected repeatedly into the bursa. Wertheim and Rovenstine [661] believe that an analgesic block of the suprascapular nerve at the suprascapular notch is the procedure of choice to relieve pain about the shoulder. After the use of 5 cc. of 5 per cent intracaine (β-diethylaminoethyl-p-ethoxybenzoate hydrochloride) in oil analgesia persisted for several weeks. Physical therapy and other procedures could then be carried out without pain. [ED. NOTE: Injections about the suprascapular nerve lead to anesthesia chiefly about the posterior aspect of the shoulder, but the method is simple and sometimes effective.]

Sutro and Cohen [662] studied 34 patients with calcification in the tendons of the shoulder for vitamin deficiency. Eight patients were given tocopherol, but they showed no more rapid subsidence of symptoms than control patients. Dick, Hunt and Ferry [663] report giving 1 Gm. of ammonium chloride four times a day to patients with calcification of

657. Bosworth, B. M.: Examination of Shoulder for Calcium Deposits: Technic of Fluoroscopy and Spot-Film Roentgenography, J. Bone & Joint Surg. **23**: 567-577 (July) 1941.

658. Cleaves, E. N.: New Film Holder for Roentgen Examination of Shoulder, Am. J. Roentgenol. **45**:288-290 (Feb,) 1941.

659. Cherry, J. H., and Ghormley, R. K.: Bursa and Ganglion, Am. J. Surg. **52**:319-330 (May) 1941.

660. Stumpfegger, L.: Obliteration Processes in Clauden Therapy of Chronic Synovial Bursitis, Zentralbl. f. Chir. **68**:779-782 (April 26) 1941.

661. Wertheim, H. M., and Rovenstine, E. A.: Suprascapular Nerve Block, Anesthesiology **2**:541-545 (Sept.) 1941.

662. Sutro, C. J., and Cohen, L. J.: Basis and Treatment of Calcification of Tendinocapsular Tissues, Especially Supraspinatus Tendon, Arch. Surg. **42**:1065-1071 (June) 1941.

663. Dick, G. F.; Hunt, L. W., and Ferry, J. L.: Calcification of Supraspinatus Tendon: New Treatment, J. A. M. A. **116**:1202-1205 (March 22) 1941.

the supraspinatus tendon. More rapid disappearance of the calcium deposit was observed.

Roentgen Therapy.—Roentgen therapy has been advocated for peritendinitis calcarea. Pinner and Staderman [664] treated 56 patients with calcification in tendons; in 52 of these the calcification was in the supraspinatus tendon. Seventy to 100 r was given over the shoulder area every other day until the symptoms subsided. Rarely were more than five treatments necessary. Marked clinical improvement was noted in all cases. Longer treatment was sometimes required in the chronic cases. There was usually rapid absorption of the calcium deposit. A comparison between diathermy and roentgen treatment is made by Solomon and Morton.[665] Twenty-five patients with periarthritis of the shoulder were treated with roentgen therapy. In each group 60 per cent were relieved of their symptoms.

Roentgen treatment is advocated for subacromial bursitis by Jones,[666] who reports the treatment of 14 patients with relief of symptoms in all of them. At each treatment 350 r was given. More than one treatment was required for most of these patients. [ED. NOTE: Relief of pain from subacromial bursitis usually follows roentgen treatment, but physical therapy and at times manipulation are required to regain full motion in the shoulder joint in the chronic cases.]

Recurrent Dislocation of the Shoulder.—Recurrent dislocation of the shoulder is discussed by Ahlberg.[667] He reports a procedure similar to that of Nicola. The long head of the biceps is cut in the intertubercular groove and sutured to the bone. The distal end is sutured to the bone below the tuberosity. Heger [668] reports the relieving of recurrent dislocation of the shoulder by injecting the patient's blood at five day intervals and keeping the arm in a sling. About 6 cc. of blood is injected into the articular capsule through the deltoid muscle. No case records are given.

Conditions Resulting from Injuries About the Head of the Humerus.—Lesions about the head of the humerus are not uncommon with dis-

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664. Pinner, W. E., and Staderman, A. H.: Peritendinitis Calcarea, with Particular Reference to Calcification in Supraspinatus Tendon, U. S. Nav. M. Bull. **39**:521-532 (Oct.) 1941.

665. Solomon, W. M., and Morton, J. L.: Periarthritis of the Shoulder: Comparison of Results Obtained by Physical Therapy and by Roentgen Therapy, Arch. Phys. Therapy **22**:607-610 (Oct.) 1941.

666. Jones, O. O.: X-Ray Treatment of Subacromial Bursitis, New Orleans M. & S. J. **93**:363-366 (Jan.) 1941.

667. Ahlberg, A.: Therapy of Habitual Dislocation of the Shoulder, Acta chir. Scandinav. **84**:557-565, 1941.

668. Heger, B.: Conservative Treatment of Habitual Luxation of the Shoulder, Wien. med. Wchnschr. **91**:22-24 (Jan. 11) 1941.

location of the shoulder and in professional athletes. Hill and Sachs [669] report that a frequently unrecognized fracture in the posterolateral aspect of the humeral head occurs with dislocations. At this region a compression fracture can be demonstrated by roentgenograms which show this posterolateral portion of the humeral head. Lesions in the bicipital groove can be demonstrated by roentgenograms taken with the patient supine and with the arm adducted and supinated, state Sachs, Hill and Chuinard.[670] Occasionally there is an additional groove lateral to the original one. Bennett [671] describes hypoplasia of cartilage, the development of loose bodies in the elbow joints and osteoarthritic deposits about the posterior part of the shoulder joint in professional athletes, particularly baseball pitchers, due to injury sustained in pitching. He obtains relief of symptoms and fairly normal function by the removal of osteoarthritic deposits and loose bodies at the shoulder and elbow joints. While such procedures may relieve symptoms, they rarely make possible a continuance of pitching baseball.

Muscle and Tendon Rupture.—Muscular and tendinous ruptures may occur in the neck and the shoulder. Wuthrich [672] reports the rupture of the distal tendon of the biceps brachii muscle. The torn tendon was sutured to the radial tuberosity with silk. The patient was doing full work as a laborer six months later. Rupture of the long head of the biceps brachii is said to be rare by Long.[673] Such a rupture on both sides is reported in a 31 year old man. Operation led to little improvement in function. A rupture of the pectoralis major muscle is reported by Pulaski and Chandlee [674] in a 67 year old man who fell and caught hold of a railing. Suturing of the muscle to the chest wall led to full recovery. Wenger [675] reports a tear in the omohyoid muscle by rupture of its binding fascia. This produced a slight tumor in the neck, a pulmonary hernia. Suture of the fascia led to disappearance of the tumor.

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669. Hill, H. A., and Sachs, M. D.: Grooved Defect of Humeral Head, Frequently Unrecognized Complications of Dislocations of Shoulder Joint, Radiology **35**:690-700 (Dec.) 1940.

670. Sachs, M. D.; Hill, H. A., and Chuinard, E. L.: Further Studies of Shoulder Joint with Special Reference to Bicipital Groove, Radiology **36**:731-735 (June) 1941.

671. Bennett, G. E.: Shoulder and Elbow Lesions of Professional Baseball Pitcher, J. A. M. A. **117**:510-514 (Aug. 16) 1941.

672. Wuthrich, A.: Subcutaneous Rupture of Terminal Tendon of Biceps Brachii, Beitr. z. klin. Chir. **171**:370-375, 1940.

673. Long, L. P.: Bilateral Independent Rupture of Long Head Division of Biceps Brachii, Am. J. Surg. **51**:684-688 (March) 1941.

674. Pulaski, E. J., and Chandlee, B. H.: Ruptures of Pectoralis Major Muscle, Surgery **10**:309-312 (Aug.) 1941.

675. Wenger, H. L.: Subclavicular Dislocation of Omohyoid Muscle by Rupture of Its Binding Fascia, J. Bone & Joint Surg. **23**:682-683 (July) 1941.

Acromioclavicular and Coracoclavicular Conditions.—A method of treatment of acute acromioclavicular dislocation is described by Hart.[676] He applies a plaster spica cast with the arm in 45 degrees abduction. Downward pressure is applied by straps and a pad on the acromion for six to eight weeks. After four weeks the upper half of the arm cast is removed, and exercises are given.

Two methods of operative repair of acromioclavicular dislocation are reported. Mumford,[677] while believing that most patients recover with conservative treatment, advises operation if symptoms persist. Absence of part of the clavicle does not lead to disability. To relieve the pain of acromioclavicular dislocation he removes the distal end of the clavicle. Four cases are reported with prompt relief of symptoms and return to work in three to four weeks. B. M. Bosworth[678] advises the suspension of the scapula from the clavicle for acromioclavicular separation. This is done by fixing the clavicle to the coracoid process with a single vitallium screw. No support is required postoperatively, but heavy work is not permitted for six weeks.

Abnormalities of the clavicle and its articulations have been reported occasionally. Nutter[679] reports 12 examples of coracoclavicular articulations in 1,000 patients; in 6 patients the articulation was present on both sides. Slocum[680] reports 1 case of bilateral coracoclavicular articulation without symptoms.

Cervical Rib and the Scalenus Anticus Syndrome.—Stammel[681] has observed a fracture of a cervical rib which occurred in an automobile accident. There were no special symptoms. Hadley[682] found cervical ribs in 1 per cent of autopsies. He believes that there is a hereditary tendency to this abnormality. Late symptoms come from weakening and depression of the shoulder girdle.

A new method of treatment of pain resulting from spasm of the scalenus anticus muscle is described by Kaplan.[683] He injects a solution

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676. Hart, V. L.: Treatment of Acute Acromioclavicular Dislocation, J. Bone & Joint Surg. **23**:175-176 (Jan.) 1941.

677. Mumford, E. B.: Acromioclavicular Dislocation: New Operative Treatment, J. Bone & Joint Surg. **23**:799-802 (Oct.) 1941.

678. Bosworth, B. M.: Acromiocavicular Separation: New Method of Repair, Surg., Gynec. & Obst. **73**:866-871 (Dec.) 1941.

679. Nutter, P. D.: Coracoclavicular Articulations, J. Bone & Joint Surg. **23**:177-179 (Jan.) 1941.

680. Slocum, D. B.: Coracoclavicular Joint, Northwest Med. **40**:16 (Jan.) 1941.

681. Stammel, C. A.: Bilateral Cervical Ribs: Report of Case with Fracture of Left, Am. J. Roentgenol. **45**:730 (May) 1941.

682. Hadley, H. G.: Cervical Ribs, J. Maine M. A. **32**:197-198 (Aug.) 1941.

683. Kaplan, L.: Relation of Scalenus Anticus Muscle to Pain in Shoulder: Diagnostic and Therapeutic Value of Procaine Infiltration, Arch. Surg. **42**:739-757 (April) 1941.

of procaine hydrochloride into the scalenus anticus muscle. Seventy-eight injections were given to 40 patients without any untoward effect. Most of the patients were completely relieved. Sometimes permanent relief resulted from a single injection.

Conservative treatment is advocated by Hansson [684] for the cervicobrachial syndrome. He finds that an analysis of cases shows that in 85 per cent operation is not performed. In all cases the condition is related to the superior outlet of the thorax. The structures which may increase tension on the vessels and nerve fibers are: (1) a high first rib; (2) a cervical rib; (3) a spastic scalenus muscle; (4) increased traction from within the thorax, and (5) increased traction by the scapula and the upper extremity. The author advocates rest and support with an airplane splint or a figure of eight bandage for the cases in which the condition is in an early stage. Exercises for maintaining the shoulder high and correcting posture are given. Head correction is delayed because holding the head erect may increase tension on the brachial plexus. Surgical correction is reserved for those who do not respond to this treatment.

Cleidocranial Dysostosis.—A case of cleidocranial dysostosis is reviewed by Tuggle and Mitton.[685] There was a defect in the midportion of the clavicle. Frequently no inconvenience or weakness results from the deformity. Complications are more frequently psychologic than physical.

Conditions About the Scapula.—Two cases of scapula alata are reported by Foley and Wolf.[686] These resulted from paralysis of the serratus magnus muscle. In one the paralysis of the serratus muscles followed an abdominal operation. In the other the condition was caused by infantile paralysis. They describe a spinal brace with pads over the scapula which improves function and makes the deformity inconspicuous.

Brunnstrom [687] has studied 17 cases of isolated paralysis of muscles about the scapula. This has given her an excellent opportunity for studying the isolated function of these muscles on the opposite side. She finds that isolated paralysis of the trapezius muscle did not interfere appreciably with elevation of the arm. Isolated paralysis of the serratus magnus muscle caused much disability; the arm could not be elevated above the horizontal position. The levator scapulae muscle can take

684. Hansson, K. G.: Cervicobrachial Syndrome, Arch. Phys. Therapy **22**: 662-666 (Nov.) 1941.

685. Tuggle, A., and Mitton, K. L.: Clavicular Dysostosis, Am. J. Roentgenol. **45**:728-729 (May) 1941.

686. Foley, W. E., and Wolf, J.: Scapula Alata, J. Iowa M. Soc. **31**:424-426 (Sept.) 1941.

687. Brunnstrom, S.: Muscle Testing Around Shoulder Girdle, J. Bone & Joint Surg. **23**:263-272 (April) 1941.

over the function of the upper trapezius muscle, and the serratus can take over the function of the lower trapezius.

The Jaw.—Kleinberg [688] reports a case of unilateral dislocation of the temporomandibular joint caused by the forceful extraction of a tooth. There was a history of repeated attacks of locking and stiffness for three months. The joint was exposed through a vertical incision anterior to the temporal artery, curving 45 degrees anteriorly above the joint line. At operation a degenerated cartilage was found, and there was a ridge of bone on the anterior margin of the joint. The removal of these led to free movement in the temporomandibular joint. There was complete recovery.

Extra-articular bony ankylosis of the temporomandibular joint is reported by Berger.[689] This occurred in a 4 year old Negro boy after multiple fractures of the facial bones from the kick of a horse. The removal of a mass of bone which joined the coronoid process to the mandible led to the return of movement.

Beckwith [690] has observed that disturbances in the balance of occlusion of the teeth cause changes in the temporomandibular joint. Symptoms of this may be centered about the ear or may travel along the sensory branches of the fifth nerve. Sheets [691] reports that abnormalities of the jaw can give rise to certain common complaints, e. g. temporary impairment of the hearing, buzz in the ear, pain and tenderness about the ear, dizziness and headache, particularly if the molar teeth are lacking. The condylar head might push on the meniscus rather than guide it. Treatment consisted in resting the joint. In severe cases wiring may be required.

XVIII. CONDITIONS INVOLVING THE ELBOW, FOREARM, WRIST AND HAND

Surgical Approaches to the Elbow Joint.—The Kocher incision is praised by Bertola.[692] He modifies the skin incision by displacing it backward halfway between the epicondyle and the posterior midline through the olecranon process. He extends the incision from about 6 cm. above the olecranon process to 6 cm. below, curving it like an

688. Kleinberg, S.: Traumatic Internal Derangement of Temporomandibular Joint, Am. J. Orthodontics (Oral Surg. Sect.) **27**:328-332 (June) 1941.

689. Berger, A.: Intra-Articular Bony Ankylosis of Temporomandibular Joint, Bull. Hosp. Joint Dis. **2**:27-33 (Jan.) 1941.

690. Beckwith, J. H.: Observations Concerning Temporomandibular Joint, Bull. Jackson Mem. Hosp. **3**:74-78 (Jan.) 1941.

691. Sheets, C. E., Jr.: Temporomandibular Joint, Mil. Surgeon **88**:529-538 (May) 1941.

692. Bertola, V. J.: New Incision for Elbow, Prensa méd. argent. **28**:479-484 (Feb. 26) 1941.

extended S to end by crossing the posterior midline, much as in the Kocher incision. By displacing Kocher's skin incision a few millimeters posteriorly, the author hopes to protect the cutaneous nerves and to respect more fully Langer's lines of tension, thus avoiding painful scars. For the remainder of the exposure Kocher's technic is used. [ED. NOTE: Never having observed a painful scar after years of using the Kocher incision, one of us (W. P. B.) sees little reason for this new incision.]

Kaplan [693] emphasizes the importance of pronation and supination of the forearm during exposure of the radial head. He suggests having the patient in a prone position with the forearm pronated so that the little finger is up from the arm board. His incision is carried from 1½ inches (3.8 cm.) above the epicondyle and directly over the epicondylar ridge distally for about 2 inches (5 cm.) below the radiohumeral joint. It separates the brachioradialis and the two radial extensor muscles of the carpus laterally and the extensor digitorum communis muscle medially. The supinator muscle is identified in the depths. The writer demonstrates the greater vulnerability of the posterior branch of the radial nerve with the forearm in supination and warns against this position. [ED. NOTE: The prone position of the patient certainly simplifies exposure of the radial head and merits Leo Mayer's recommendation.]

Avulsion of the Distal Biceps Brachii Tendon.—Avulsion of the distal biceps brachii tendon is so rare that little has appeared in the literature concerning this injury. Dobbie [694] presents a new case of his own and 1 of Plummer's. In one the biceps tendon was split and sutured to the tendon of the brachialis muscle, and in the other it was passed blindly through its normal tunnel and sutured with fascia to the ulna. In addition to these the writer reports 49 additional cases uncovered by four hundred and ninety inquiries, to 72.6 per cent of which there were replies. The mechanism of repair in these cases varied from actual replacement of a tendon on the bicipital tuberosity, or looping of fascia around the radius, to suturing the tendon to the brachialis muscle, the brachioradialis muscle, the lacertus fibrosus or adjacent fascia. The predominant method of repair was suture with silk through drill holes in the bicipital tuberosity.

The diagnosis apparently presented no difficulty, although it was impossible to differentiate clinically between avulsion and actual rupture of the biceps tendon. The subject is summarized, and the results are tabulated. Twenty-four cases are added from the literature, making a

693. Kaplan, E. B.: Surgical Approach to Proximal End of Radius and Its Use in Fractures of Head and Neck of Radius, J. Bone & Joint Surg. **23**:86-92 (Jan.) 1941.

694. Dobbie, R. P.: Avulsion of Lower Biceps Brachii Tendon: Analysis of Fifty-One Previously Unreported Cases, Am. J. Surg. **51**:662-683 (March) 1941.

total of 75. From a review of all of these it seems that the results are equally satisfactory whether the tendon is attached to the radius or to the adjacent soft parts of the forearm. In connection with reattaching the tendon to the radius complications arose in 2 cases, and the writer warns against the use of the more complicated method. After Dobbie's article had been published, an additional case was reported independently by Sharpe.[695] He found the lacertus fibrosus torn and frayed and the tendon coiled on itself. After exposure of the radial neck, the tendon was sutured to the bone with chromic catgut through drill holes. The author describes the operation as tedious. A case which was unknown to Dobbie was simultaneously reported by Ringel[696] of Schmieden's clinic at Frankfurt on the Main, Germany. He obtained a good result by suturing the avulsed tendon to the lacertus fibrosus and the surrounding soft parts. He emphasizes the simplicity of the technic and the good end results. Ringel's bibliography duplicates five of Dobbie's references and furnishes nine additional ones.

An interesting case is reported by Wolfe[697] in which a traumatic partial rupture of the lower end of the muscles from the tendon made diagnosis difficult. Repair of the ruptured portion resulted in complete recovery.

[ED. NOTE: Dobbie's collected experiences and opinions establish the fact that the inclination of most surgeons on being suddenly confronted with an avulsed tendon is to replace it accurately. Certainly the easier operation is to be preferred, and the end results justify this procedure.]

Roentgenography of the Wrist.—More accurate roentgen studies of the carpal canal are urged by Hart and Gaynor.[698] A tangential view of the palmar surface of the wrist with the fingers and the hand dorsiflexed outlines the carpal canal with the pisiform bone and the hook of the hamate bone on one side and the tubercle of the navicular bone and the crest of the greater multangular bones on the other side. In a second article[699] he demonstrates the utility of this projection in revealing a fracture of the ridge or the tuberosity of the greater multangular bone and in visualizing the area in which the hook of the hamate bone bruised the ulnar nerve.

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695. Sharpe, W. E., Jr.: Avulsion of Distal Tendon of Biceps Brachii, Am. J. Surg. **54**:733-736 (Dec.) 1941.

696. Ringel, W.: The Clinical Aspects and Therapy of Avulsion of the Lower Biceps Tendon, Zentralbl. f. Chir. **68**:871-875 (May 10) 1941.

697. Wolfe, H. R. I.: Traumatic Rupture of the Biceps Brachialis, J. Roy. Nav. M. Serv. **27**:290-292 (July) 1941.

698. Hart, V. L., and Gaynor, V.: Roentgenographic Study of Carpal Canal, J. Bone & Joint Surg. **23**:382-383 (April) 1941.

699. Hart, V. L.: Two Unusual Injuries of the Wrist, J. Bone & Joint Surg. **23**:948-949 (Oct.) 1941.

Anatomy of the Wrist.—MacConaill [700] finds that according to function the carpus must be divided into three units. These comprise the navicular bone, the lunate and triquetral bones together and the distal mass formed of the hamate, capitate and trapezoid bones together. This includes all of the bones between the forearm and the metacarpal bones, second to fourth inclusive. The navicular bone is separated from the other two groups because it moves with the distal row in the earlier stages of volar flexion and with the proximal row in the later stages. Conversely, it moves with the proximal row in the early stages of dorsiflexion and with the distal row in the later stages. In dorsiflexion of the hand the muscular forces pulling on the metacarpal bones transmit the force directly to the hamate, capitate and trapezoid bones. These three bones rotate about an axis which passes through the head of the capitate bone at the glenoid fossa of the navicular bone. The ligaments connecting the bones shorten and draw the bones tightly together, locking them with a screwlike motion which is best studied in a fresh dissection. In the second stage of dorsiflexion, the lunate and triquetral bones are screwed against the navicular bone and brought to rest tightly against it so that the writer likens the whole mechanism to a screw clamp with both rows of bones being screwed tightly against the navicular bone. The movement of the bones in radial and ulnar deviation of the hand is also traced. As a result of an extensive study of the anatomy of the bones of the wrist it is suggested that the usual manipulation of the wrist be reversed in the reduction of dislocation of the carpal semilunar bone. Volar flexion is shown to open the space and permit easy reduction. Dorsiflexion is used to close the space and lock the bone in position. The latter position is fixated in plaster. The method has been used successfully in 9 cases of fresh dislocation.

This anatomic observation may have bearing on midcarpal dislocation, such as the one described by Scott [701] in a British soldier. The semilunar bone and the proximal third of the fractured scaphoid bone maintained their normal relation to the radius. The remaining carpal bones were displaced, dorsally, radially and proximally.

Carter [702] calls attention to the occurrence of a bony tumor on the dorsum of the wrist associated with aching and rapid fatigue of the hand. Overgrowth of bone similar to a pair of osteophytes occurs on either side of the third metacarpal-capitate joint. Various theories of causation have been advanced. The writer considers the lesion to be

700. MacConaill, M. A.: The Mechanical Anatomy of the Carpus and Its Bearings on Some Surgical Problems, J. Anat. **75**:166-175 (Jan.) 1941.

701. Scott, L. G.: Unusual Dislocation of the Carpal Bones, Brit. M. J. **1**:855 (June 7) 1941.

702. Carter, R. M.: Carpal Boss: Commonly Overlooked Deformity of Carpus, J. Bone & Joint Surg. **23**:935-940 (Oct.) 1941.

of gradual development. Isolated trauma seems to play no part. In 2 cases in which operation was performed to remove the protruding bone, recurrence was prompt. In a personal communication to the author Lambert notes two recurrences after two operations in a similar case. Carter concludes that operation is of little value. The clinical entity is largely of medicolegal interest. [ED. NOTE: Carter has performed a real service in calling the attention of the orthopedic surgeons to this clinical entity which should apparently be left alone or treated conservatively.]

Ganglions of the wrist and the hand are treated by Lyle [703] with roentgen therapy. Six of 21 patients have been followed for five years. Examination and questionnaires have shown that 17, or 81 per cent, of the tumors disappeared. Fourteen, or 78 per cent, of the patients complaining of pain were relieved, and 9, or 82 per cent, of those complaining of weakness had a return of normal function. In general, 17 had good results; 1 was improved; 2 were not improved, and 1 was not heard from. From one to eight treatments were necessary. If after the first treatment the tumor disappeared in a month, the treatment was considered sufficient. When the tumor persisted, 1½ erythema dose of radiation was given each month until results were obtained. If more than five treatments were necessary, the interval between treatments was increased. A distance of 23 cm. was used with no filter. [ED. NOTE: Evaluation of end results must be extremely guarded when considering a lesion which frequently disappears spontaneously. The indication for treatment of a ganglion should be pain and weakness. The frequent relief of these symptoms with Lyle's treatment recommends it as sound.]

Lotsch [704] urges substitution of the term "arthroma" for the inaccurate designation "ganglion." After trying a great variety of forms of treatment, he has finally decided in favor of aspiration and injection of an iodine solution.

Madelung's Deformity.—A classical case of Madelung's deformity is reported by the Rochers.[705] For the treatment of this condition Hucherson [706] recommends the Darrach operation. An incision is made longitudinally on the ulnar aspect of the forearm, extending from the tip of the ulnar styloid proximally. It is carried down to the periosteum

703. Lyle, F. M.: Radiation Treatment of Ganglia of Wrist and Hand, J. Bone & Joint Surg. **23**:162-163 (Jan.) 1941.

704. Lotsch, F.: Nature and Therapy of Tendon Sheath Ganglion: Suggested Change in Nomenclature to "Arthroma." Med. Klin. **36**:676-677 (June 21) 1940.

705. Rocher, H. L., and Rocher, C.: Madelung's Disease: New Case, J. de méd. de Bordeaux **117**:225-228 (April 20-27) 1940.

706. Hucherson, D. C.: Darrach Operation for Lower Radioulnar Derangement, Am. J. Surg. **53**:237-241 (Aug.) 1941.

between the flexor and extensor carpoulnar tendons. Care must be taken to avoid the dorsal branch of the ulnar nerve. The periosteum is then reflected from the lower portion of the ulna, and the bone is cut across obliquely, leaving the proximal fragment with a sloping margin. The lower fragment is then turned out of the wound, and the attachment of the capsule is divided close to the articular cartilage. The ulnar styloid is then cut across at its base and left behind with its attached collateral ligament. The periosteum is closed. The attachment is strong enough to prevent abduction laxity.

Alexander and Johnson [707] record a case of Madelung's deformity in which in addition to the typical deformity, roentgen examination showed bilateral fusion of the semilunar and cuneiform bones.

In a case of trauma simulating Madelung's deformity, Marottoli and Broca [708] obtained a good result from excision of the triangular radiolunar fibrocartilage. They emphasize the simplicity of this procedure in contrast to plastic operations on this ligament or on the annular ligaments. [ED. NOTE: The recurrence of discussions of Madelung's deformity in the literature and the multiplicity of therapeutic suggestions indicate clearly that the problem is far from solved.]

DeQuervain's Disease.—In 40 cases of deQuervain's disease, Weissenbach and Francon [709] obtained cures in 35 with conservative treatment, for the most part with hydrotherapy. The writers recommend immobilization and administration of sedatives for three weeks. If the symptoms are not relieved, thermal treatment without massage is instituted. If the symptoms persist after two months, surgical intervention is indicated. Wilberg [710] has studied 23 cases in which operation was done and reports 8 in detail. In isolated cases there seems to be a definite relation between this lesion and trauma. To impute trauma the author requires a definite history of injury or operative findings clearly indicating scarring of the tendon. [ED. NOTE: The variable response to therapy of this condition as indicated by studies of end results is undoubtedly due to the variable causation. Infectious and traumatic causes are predominant. Both factors may be operating to produce the symptoms. In the face of infection conservative therapy

707. Alexander, H. H., and Johnson, G. H.: Dyschondroplasia of Distal Radial Epiphysis (Madelung Deformity), with Fusion of Semilunar and Triangular Cuneiform Bones, Am. J. Surg. **53**:349-351 (Aug.) 1941.

708. Marottoli, O. R., and Broca, M.: Fibrocartilaginous Lesions of Inferior Radiocubital Joint, Dia méd., December 1940 (Ed. espec., no. 10), pp. 205-206.

709. Weissenbach, R. J., and Francon, F.: Chronic Stenosing Tenosynovitis (de Quervain's Disease): Symptoms, Diagnosis and Therapy, Rev. argent. de reumatol. **5**:299-305 (March) 1941.

710. Wilberg, G.: De Quervain's Tendovaginitis as Sequel to Injuries of the Hand, Nord. med. (Hygiea) **10**:1929-1933 (June 21) 1941.

should be stubbornly adhered to. When the cause is exclusively traumatic and cicatricial contractures are present, immediate operation is justified.]

Anatomy of the Hand.—From studies based on dissection, injection and section of 92 adult human hands, Grodinsky and Holyoke [711] would like to revise the conception and the nomenclature with regard to fascial spaces of the palm. They describe midpalmar, adductor, thenar and hypothenar palmar spaces as distinct entities. They bound these accurately. Injection into the midpalmar space of small amounts of gelatin filled only one or two compartments. Increasingly large quantities filled the entire midpalmar space and extended along the lumbrical muscles distally toward their insertion dorsally. Still larger volumes resulted in the rupture of the oblique septum with extension into the adductor space. This term is used instead of the thenar space of Kanavel. The writers describe thenar and hypothenar spaces which are of little importance clinically because infections within them remain localized and bear no important relations to other spaces or sheaths. The serous tendon sheaths and the fibrous sheaths also are described. The writers differ somewhat with the findings published by Anson and Ashley.[711a]

In an interesting study of 913 residents of the island of Formosa, Hikita, Kasiba and Hamasaki [712] have compared the lengths of the index and ring fingers. There seemed to be no sexual variation. On the average, the index finger was longer than the ring finger. The reverse was true of both hands in 12 per cent, of the right hand in 24 per cent and of the left hand in 6 per cent. [ED. NOTE: This is another illustration of the variation within normal limits.]

Dupuytren's Contracture.—Dupuytren's contracture has come up for discussion on all sides again during the past year. Meyerding and associates [713] offer an excellent summary of the subject. On the basis of microscopic study in 57 cases the lesion is explained as a chronic inflammatory process involving the skin, the subcutaneous tissue and the interstitial connective tissue as well as the palmar fascia. The authors warn against confusion with fibrosarcoma. They emphasize the surgical skill necessary for treatment and offer no gadgety solution to

711. Grodinsky, M., and Holyoke, E. A.: Fasciae and Fascial Spaces of Palm, Anat. Rec. **79**:435-451 (April 25) 1941.

711a. Anson, B. J., and Ashley, F. L.: Midpalmar Compartment, Associated Spaces and Limiting Layers, Anat. Rec. **78**:389-407 (Nov. 25) 1940.

712. Hikita, K.; Kasiba, M., and Hamasaki, Y.: Relative Length of Fingers, Taiwan Igakkai Zassi **40**:415 (Feb.) 1941.

713. Meyerding, H. W.; Black, J. R., and Broders, A. C.: Etiology and Pathology of Dupuytren's Contracture, Surg., Gynec. & Obst. **72**:582-590 (March) 1941.

the problem. Adams [714] also emphasizes the good results which may be obtained by painstaking, time-consuming, delicate operation and warns against longitudinal incisions. [ED. NOTE: Meticulous operation is certainly the answer to the problem of Dupuytren's contracture. Longitudinal connecting incisions, if kept at the ulnar border of the palm as descriped by Koch, have not caused contractures.] Couceiro [715] reports a single case. He is impressed with the element of neurotrophic change. [ED. NOTE: His eleven references are from South American journals only; six of these are found in the *Revue neurologique*. He should read the article by Meyerding and associates.] Stern [716] suggests a new operative technic. After preliminary exposure he divides the palmar fascia longitudinally on a grooved director. Multiple cuts are made over the tendon sheaths and over the vessels and the nerves. With this start the deep septums are dissected out. The author reports 1 case. Use of a tunnel graft to relieve skin contractures is suggested by Skinner.[717] [ED. NOTE: The literature on Dupuytren's contracture is now voluminous. If each new writer were to read a few of the good existing articles and then perfect a meticulous surgical technic, fewer aids in the treatment would be necessary. Badly contracted skin will frequently stretch after the fascia has been removed. One should not be in a hurry to sacrifice skin. There are still unknown factors in the causation. The hereditary element must not be overlooked.]

Grease Gun Injuries of the Hand.—Another case of oil penetration of tissue is reported by Hughes.[718] Accidental tripping of the compressor of a Diesel engine while the nozzle was in contact with the palm of a worker's hand injected 2 to 3 cm. of Diesel oil into the palm at the base of the middle and ring fingers. Intractable pain soon followed numbness. Gangrene of the fingers necessitated amputation. Several questions are raised which are well answered by Mason and Queen.[719] They report 2 cases. Both injuries were caused by grease guns. In the first case a primary incision was made soon after the injury at the site of entrance of the oil into the palm. Considerable

714. Adams, H. D.: Dupuytren's Contracture, Lahey Clin. Bull. **2**:75-78 (Jan.) 1941.

715. Couceiro, A.: Dupuytren's Contracture: So-Called Retraction of Palmar Aponeurosis: Case, Neurobiologia **3**:396-403 (Dec.) 1940.

716. Stern, E. L.: New Operative Procedure for Dupuytren's Contracture, Am. J. Surg. **54**:711-715 (Dec.) 1941.

717. Skinner, H. L.: Operative Correction by Use of Tunnel Skin Graft for Dupuytren's Contracture, Surgery **10**:313-317 (Aug.) 1941.

718. Hughes, J. E.: Penetration of Tissue by Diesel Oil Under Pressure, J. A. M. A. **116**:2848-2849 (June 28) 1941.

719. Mason, M. L., and Queen, F. B.: Grease Gun Injuries to Hand: Pathology and Treatment of Injuries (Oleomas) Following Injection of Grease Under High Pressure, Quart. Bull. Northwestern Univ. M. School **15**:122-132, 1941.

grease was expressed. The incision healed but reopened to discharge pus. Later the writers dissected out numerous encapsulated and infiltrating greasy tumors which extended down to the fibrous sheath of the flexor tendon of the index finger and to either side of the phalanx, where the mass surrounded the digital nerves and vessels. There were numerous smaller prolongations necessitating a "long and painstaking dissection." In the second case there was penetration of the left index finger with grease when a grease gun exploded. Grease could be squeezed from a dotlike puncture wound on the palmar surface on the distal phalanx. A month after the injury the finger tip became enlarged and was finally operated on six months later. The subcutaneous tissues of the anterior closed space were found to have been converted into a dense grayish mass resembling scar tissue and containing numerous grossly visible cystic areas filled with gray oily fluid. The overlying skin was adherent to the mass and apparently involved in the same process over one half of the area of the volar surface of the phalanx. The fibrous and cystic process extended throughout the whole of the subcutaneous tissues of the phalanx down to the periosteum and the fibrous tissues over the insertion of the flexor digitorum profundus tendon. The involvement of the skin was not so great in extent as that of the subcutaneous tissues. All diseased tissue was removed and a flap graft used.

The irritating effect of oil or paraffin in the tissues has been well known for many years. It is not surprising, therefore, that various industrial oils and greases, if introduced accidentally or intentionally, should also cause disturbance. In the case of injection under great pressure there is added to the irritative effect of the oil itself the great distention of the tissues with the likelihood of subsequent gangrene. This holds true particularly when closed spaces are involved, as, for example, when the fingers are affected. Late manifestations of extensive fibrosis and granulomatous lesions well beyond the area of original involvement are inevitable. It is therefore advisable to attempt removal of the oleoma even in those instances in which it is present as a symptomless nodule under the skin.

Epithelial Cysts.—Yachnin and Summerill [720] report an additional case of "traumatic" implantation of an epithelial cyst in the terminal phalanx of the right fourth finger following a crushing injury with avulsion of the nail. Two years later pain appeared at the tip of the finger. Roentgen examination revealed a circular area of destruction in the cortex of the terminal phalanx. At operation a white mass was removed which revealed on microscopic examination a thin wall formed by stratified squamous epithelium surrounding a nest of keratin debris

720. Yachnin, S. C., and Summerill, F.: Traumatic Implantation of Epithelial Cyst in Phalanx, J. A. M. A. **116**:1215-1218 (March 22) 1941.

in the formation of which there was no parakeratosis. The stratum granulosum and the rete mucosum were thick. The basal layer did not accompany these except in one place, where only a minute fragment was attached. The cyst apparently is the result of traumatic implantation of epithelial cells and not of traumatic stimulation of growth of cells of congenital inclusion.

Becker [721] reports 2 similar cases of pavement epithelial cysts of the distal phalanges of fingers. In the first case an amputation of half of the distal phalanx was performed three weeks after the injury. At this time there was a fracture through a cyst. Microscopic examination showed cystic areas lined with pavement epithelium. It appeared that the epithelial tissue was forced into the bone. However, no direct connection between the skin and the bone could be determined. A diagnosis of traumatic epithelial cyst was made. In the second case the roentgen and the clinical appearance were somewhat similar, but the cyst was minute. There was a history of only minor finger injuries. In this case a small white kernel was shelled out of the bone. The tumor was preponderantly epithelial tissue, and a diagnosis of epithelial tumor with marked degeneration was made. It was less definitely from the skin than in the previous case. The writer cites 9 cases from the literature. He inclines to a theory of traumatic origin, even though there is no definite history of injury. It is known that comparatively minor trauma suffices to introduce epithelial cysts into the soft parts. It is suggested that the history is sometimes inadequate to disclose the trauma causing the origin of the cyst. The author urges preoperative recognition to avoid the necessity of partial amputation. [ED. NOTE: A long interval between injury and discovery does not prove traumatic origin, but a short interval (three weeks) does exclude it.]

Tendon Injuries.—The treatment of tendons in compound injuries of the hand is presented by Bunnell [722] in his usual simple but masterly fashion. Fine stainless steel wire is advocated instead of silk, which is the next best suture material for tendons. Various stitches are shown. A simple figure of eight stitch for primary suture of extensor tendons is used in connection with splinting. The deep loop unites the tendon ends and the superficial one the skin surfaces. The entire suture may be easily removed. It has no strength and depends on splinting for the relief of strain. A strong suture for interval repair buries the knot at a distance from the suture line. It has the disadvantage of leaving wire fragments in the tendon. These are less irritating physiologically than silk but may cause some mechanical difficulty. A double right angle

721. Becker, F.: Pavement Epithelium of Bones of Fingers, Chirurg **12**:275-279 (May 1) 1940.

722. Bunnell, S.: Treatment of Tendons in Compound Injuries, J. Bone & Joint Surg. **23**:240-250 (April) 1941.

stitch may be used in cases in which there is no strain and in which infection is feared. It may be used in connection with a pull out wire.

To obtain his goal of complete absence of suture material, Bunnell has devised the withdrawable tendon suture.

After a tendon is sutured, only the end of the tendon attached to the muscle exerts a pull. Therefore, the suture is spliced securely in this end, and the two ends are passed some distance down through the center of the distal tendon and on out through the skin. By pulling upon these sutures from the outside and anchoring them securely, the proximal end can be drawn down until the tendon ends are held approximated. Only one tiny stitch of blood-vessel silk or hairlike wire is then necessary for exact approximation of the tendon ends.

For the later withdrawal of the stitch a pull-out wire is left in place which will draw the stitch out backwards by its loop whenever the two stitch wires are cut. Both ends of the pull-out wire, after being placed through the loop of the stitch in the proximal tendon end, are threaded on a needle and passed up through the sheath some distance and out through the skin. The play of the wires through the sheath will allow a little movement in the tendon without strain on the juncture.

Tension is relieved by flexing the joints. The stitch wires can be anchored to the outside of the limb by passing them through adhesive plaster applied to the skin and then fastening them through a button, by "split shot" or to a loop of adhesive plaster over the end of the finger, or by tying the wire ends through a perforation in the fingernail. If any resistance is encountered when withdrawing the stitch by the pull-out wire, tension may be applied by fastening a light rubber band to the wire. At the next dressing the stitch will be out. The bend of the pull-out wire, where it loops through the stitch, should be pinched sharp, so that it will not encircle tissue.

[ED. NOTE: The value of Bunnell's contribution needs no comment. The entire article should be read carefully as there is not a word wasted. The illustrations are excellent; only his motion picture is superior in graphic teaching qualities.]

An interesting suggestion with regard to flexor tendon injuries comes from Blum.[723] He holds that one of the important adverse factors responsible for the poor results associated with division of flexor tendons is tension at the site of repair. He suggests open division of the muscle at the junction of the distal and middle thirds of the muscle to release this pull. About half of the thickness of the muscle is divided. This serves not only to relieve tension but to supply an additional ½ inch (1.3 cm.) to the tendon in cases in which this is necessary. In cases in which there is no shortening of the tendon, the increased length permits satisfactory splinting with less flexion. The cut in the muscle heals readily during the healing of the tendon. Two cases are submitted in which the procedure has been tried with success.

723. Blum, L.: Partial Myotomy in Treatment of Divided Flexor Tendons: Two Cases, Ann. Surg. **113**:460-463 (March) 1941.

Another ingenious suggestion comes from Bove.[724] In 4 cases he has transfixed divided flexor tendons in the fingers with fine wires like those of Kirschner. The wires are incorporated in plaster to prevent the tendon ends from retracting.

Fleischer-Hansen [725] reports on the end results in 261 cases in which there were three hundred and eighty-seven tendon injuries. There were 256 cases in which there were compound tendon lesions; 157 extensor tendons were affected as compared with 99 flexor tendons. With regard to function, the end results were good for 56 per cent and poor for 44 per cent of the lesions of the extensor tendons, while for the injuries of the flexor tendons only 31 per cent of the end results were good and 69 per cent were poor. The best results were obtained in the cases in which tendon suture was done on the back of the hand. In cases of injury to the flexor tendons suture of the flexor pollicis longus gave the best results. Simultaneous suture of several tendons to several fingers at once greatly lowered the percentage of good end results; in only 10 per cent of the cases in which this was done were good end results obtained.

The unsatisfactory results were blamed on certain anatomic and anatomicophysiologic factors, infection and deficient technic. It is recommended by the writer that all patients with injuries of the tendons be admitted to the hospital and not treated as outpatients.

Mouchet [726] records the late spontaneous rupture of the extensor pollicis longus tendon ten years after a Colles fracture. [ED. NOTE: This is certainly one of the longest intervals on record.]

Phalangization.—The method of Pieri of freeing and isolating the first metacarpal bone in cases in which the thumb is missing is again brought to attention. Almasanu [727] reports a case in which this treatment was successful. The operation was performed immediately after the accident which destroyed the thumb. The procedure is advocated in two articles from Russia. Rogova[728] reports a case in which there was loss of considerable of the last four metacarpal bones with preservation of the first. Function was apparently well restored.

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724. Bove, C.: Suturing of Flexor Tendons of Hand (Transfixation), M. Rec. **153**:94 (Feb. 5) 1941.

725. Fleischer-Hansen, C. C.: Lesions of Tendons and Their Prognosis with Respect to Function, Nord. med. (Hospitalstid.) **9**:88-98 (Jan. 11) 1941.

726. Mouchet, A.: Late Rupture of Extensor Pollicis Longus Tendon Ten Years After Fracture of Lower End of Radius: Case, Presse méd. **48**:1007-1008 (Dec. 11-14) 1940.

727. Almasanu, S.: Phalangization of First Metacarpal Bone: Case, Rev. de chir., Bucureşti **43**:807-809 (Nov.-Dec.) 1940.

728. Rogova, K. F.: Phalangization of First Metacarpal Bone, Khirurgiya **11**:150-151, 1939.

Shirokov [729] summarizes briefly the literature on operative replacement of the thumb. It is his opinion that Albrecht's operation is the best to date. This includes resection of the first dorsal interosseous muscle and transplantation of the insertion of the adductor pollicis muscle proximally. After anatomic studies and one preliminary operation, he obtained a good result in 1 case in which he added to Albrecht's technic by extirpating all of the adductor pollicis muscle except for the bundles of the oblique head which arise at the base of the second metacarpal bone, on the capitate bone and on the radial portion of the volar ligament. He conserved the point of attachment on the ulnar sesamoid bone. With this he combined resection of the medial portion of the abductor pollicis brevis muscle, the opponens pollicis muscle and the superficial head of the flexor brevis muscle. If the flexor pollicis longus muscle is not already adherent to a stump of the basal phalanx, it should be transplanted to the distal end of the metacarpal bone. For this method the writer claims greater range of motion for the first metacarpal bone, greater power and better cosmetic effect.

[ED. NOTE: Although the cosmetic effect of this operation is obviously inferior to that of the more complicated plastic procedures, the present international conflict will give rise to hand stumps which may be well handled by this method.]

Traumatic Edema.—Schörcher [730] emphasizes the reflex effect on the lymph vessels as well as on the blood vessels of traumatic edema of the hand. One case is reported in which six operations on the sympathetic nervous system failed. Improvement occurred after the introduction of silk suture drainage in the subcutaneous tissues from the hand to the middle of the forearm. With this procedure the edema disappeared within fourteen days.

XIX. AMPUTATIONS, APPARATUS AND TECHNIC

Amputations.—During the year of 1941 there has been a great deal of new literature pertaining to amputations and prostheses. The most important group of papers constitute chapters in a book to be published by the Council on Physical Therapy of the American Medical Association written by particularly well qualified surgeons and a carefully chosen group of artificial limb makers. Three of these papers were mentioned in last year's article on "Progress in Orthopedic Surgery." [731]

729. Shirokov, B. A.: Phalangization of First Metacarpal Bone in Plastic Restoration of Thumb: Anatomic Basis of Author's Method, Khirurgiya **11**:115-122, 1939.

730. Schörcher: Traumatic Edema of the Hand, Beitr. z. klin. Chir. **171**:176-194, 1940.

731. Progress in Orthopedic Surgery for 1940, Arch. Surg. **43**:866-932 (Nov.) 1941.

Gallie,[732] writing from experience based on 2,448 amputations of the lower extremity with the Canadian Army and Pension Board, which has functioned since the first World War, extols the end-bearing stumps such as result from a Gritti-Stokes or Symes amputation, which are not recommended by the British Ministry of Pensions. It is apparent that whereas these two amputations performed by the experienced amputator most often give good results they do not give uniformly good results when performed in a large organization, such as the British Ministry of Pensions, in which many different and inexperienced surgeons do the actual operating. A good deal also depends on the artificial limb maker's cooperation in the proper fitting of the limb for the best functioning of the stump.

Carnes [733] also advocates the end-bearing stump.

[ED. NOTE: Others with less experience should not be criticized for performing the simpler operations which are attended more often by success but which admittedly do not have the desirable end-bearing possibility.]

A modification of the Callander operation is described by Pearl.[734] He thinks it is desirable because his results were far more satisfactory than with the use of the orthodox technic. [ED. NOTE: In recent personal communications to one of us (J. W. W.), one from a member of the group of Consultants on Artificial Limbs of the Council on Physical Therapy of the American Medical Association and another from an experienced member of the Canadian Army and Pension Board, the opinion is expressed that the more complicated technic in this operation does not justify itself when end results are compared with the classical long anterior–short posterior flap operation done under a tourniquet.]

Maxeiner [735] urges the employment of what he calls a temporary tourniquet amputation in cases of extreme shock in which grave doubt exists relative to the patient's surviving the amputation of a hopelessly mutilated extremity. He employs several loops of "gum rubber tubing about the extremity at the lowest possible point at which the member must be sacrificed." Infection and putrefaction of the damaged extremity are controlled by wrapping the part below the tourniquet in a 10 per

732. Gallie, W. E.: The Experience of the Canadian Army and Pensions Board with Amputations of the Lower Extremity, Ann. Surg. **113**:925-931 (June) 1941.

733. Carnes, E. H.: Amputations, Stumps and Prostheses, War Med. **1**: 656-663 (Sept.) 1941.

734. Pearl, F. L.: Atraumatic Amputation Through the Lower Thigh (Callander): Modified Technic, Surg., Gynec. & Obst. **73**:381-387 (Sept.) 1941.

735. Maxeiner, S. R.: The Temporary Tourniquet Amputation, Minnesota Med. **24**:491-492 (June) 1941.

cent formaldehyde dressing encased in rubber sheeting. [ED. NOTE: One of us (J. W. W.) sees no reason why the usual Esmarch rubber bandage which is ordinarily used in work on an extremity could not be employed. The only difference is the constricting of a small circumferential area rather than larger areas constricted by the wider band ordinarily employed. It is suggested that in addition to this dressing another wide rubber bandage be employed over the rubber sheeting to insure the doing away with the disagreeably pungent odor.] Assurance is given that the initial pain is overcome by morphine or other sedatives and that this subsides in a few hours anyhow and that recovery from shock is surprisingly rapid. The time for the actual amputation may be elected, and the surgeon "may quite well wait a week." It will ordinarily be found that the tourniquet has cut its way through all of the soft tissue and that practically only the bone needs to be severed to obtain a satisfactory guillotine amputation.

The employment of refrigeration is advocated in a most important article by Allen [736] reporting opinions, experiences and technic from a large vascular disturbance clinic. After an extremity is thoroughly chilled to 5 C., it is found that amputations can be done painlessly and without shock. After chilling of the extremity with an ice bag technic described in detail, the amputation can be done unhurriedly at a point conveniently below the proximal level of chilling. A thorough discussion of the value of cold as a therapeutic agent, particularly, of course, with regard to diabetic and arteriosclerotic vascular disturbances, is given. The more assured survival of distal portions of extremities in which the vascular supply has been seriously diminished is claimed by the use of cold. The absence of heat diminishes the metabolic requirement to the amount of metabolism available and reacts more kindly than heat on the part affected. The use of cold in promoting healing in many other situations is discussed in a most convincing manner; this makes the article one that should be read carefully and thoughtfully in the original by all surgeons, particularly those operating on extremities. [ED. NOTE: The value of heat as a therapeutic agent has long been stressed, and it is just as important to understand the significance and value of the other extreme of temperature.]

McElvenny [737] reports a case of trauma in which the principles of refrigeration as stated by Allen were employed most successfully prior to the amputation of both legs.

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736. Allen, F. M.: Reduced Temperatures in Surgery: Surgery of Limbs, Am. J. Surg. **52**:225-237 (May) 1941.

737. McElvenny, R. T.: The Effect of Cooling Traumatized and Potentially Infected Limbs, Surg., Gynec. & Obst. **73**:263-264 (Aug.) 1941.

A German article by Angerer [738] reporting the satisfactory functional results following amputations of the toes and even the metatarsal heads necessitated by exposure to cold is reviewed. This suggests that there may be an overemphasis on the amount of disability to be expected from such operations.

A Spanish surgeon, Cotta dos Santos,[739] calls attention to the value of astragalectomy for the equinus deformities following Chopart's amputations (he calls it equinismus). [ED. NOTE: It is believed by one of us (J. W. W.) that if astragalectomy is to be considered as a retouching secondary procedure, this is a valuable article to emphasize the unsatisfactory results ordinarily to be expected from amputations of the forefoot.]

An excellent brief history of amputations from the time of Hippocrates to the first World War is given by Carnes,[738] who discusses at length various important points already adequately stressed but all worth while reviewing. This is the only article in which cinematic amputations are mentioned, but they are spoken of rather unenthusiastically. It is stated that the results are not much better than with conventional methods. [ED. NOTE: It is obvious that the technicalities of this operation confine its employment to the ultraspecialized surgeon and certainly do not permit it to be done by the occasional amputator.]

In the chapter on reasons for reamputations and secondary operations in the report of the Council on Physical Therapy of the American Medical Association on amputations,[740] the principal cause is given as too much length. Others of less importance are: sloughing or ulceration over the end of the stump, osteomyelitis or aseptic necrosis of the end of the bone, neuroma and finally neurosis. It was found that true malingering as a reason for reamputation is rare.

In another chapter [741] it is pointed out that surgeons frequently are too loath to amputate and that not enough regard is paid the patient's desires in this matter.

Brittain,[742] an English surgeon, calls attention to the advantage of performing some amputations in bed on seriously ill patients in order to facilitate the carrying out of intravenous procedures. [ED. NOTE:

738. Angerer, H.: Physical Efficiency of Mountaineers After Loss of Lower Extremities, Zentralbl. f. Chir. **67**:2250-2251 (Nov. 30) 1940.

739. Cotta dos Santos, H.: Value of Ricard Amputation Operation in Crushing of Foot with Surgical Technic, Rev. méd. munic. **1**:226-235 (Feb.) 1941.

740. Reamputations and Secondary Operations, Council on Physical Therapy, J. A. M. A. **116**:2501 (May 31) 1941.

741. Physical Therapy in Amputations, Council on Physical Therapy, J. A. M. A. **116**:1519-1523 (April 5) 1941.

742. Brittain, H. A.: Amputation in Bed, Brit. M. J. **1**:192-193 (Feb. 8) 1941.

This is a reasonable common sense article which calls attention to a point possibly not frequently enough considered. There is nothing particularly unusual about the technic suggested except possibly its urging a thorough rehearsal before performing the amputation.]

Mohs, Sevringhaus and Schmidt [743] have collaborated in an article advocating conservative amputations of gangrenous parts by fixing them with a twenty-four hour exposure to a zinc chloride paste; after this, if separation of fixed tissue has occurred, amputation is done with a scalpel and a bone rongeur. This sometimes takes several days. It is claimed that by this method freshly cut surfaces are avoided and the spread of infection is discouraged.

Willis and Teitelman [744] describe an interesting amputation technic in which after the shaping of an anterior flap a flat band retractor is passed posterior to the femoral shaft at the point of planned amputation and the posterior flap is fashioned in an unhurried manner, pressure being exerted on the uncut tissues against an underlying sterilized cork block. The retractor itself serves as a most satisfactory protector of the underlying tissues when the bone is sawed. The vessels and the nerves are easily identified and taken care of. [ED. NOTE: The chief but questionable advantage of this technic is the avoidance of a tourniquet, but it is feared that there would be a temptation to leave too long a posterior flap.]

In 1941 two articles on interscapulothoracic amputation and one on interinnominoabdominal amputation appeared. No particularly new points have been brought out, but in Strode and Fennel's [745] article the most frequent indication for such a heroic surgical procedure is given as the presence of a relatively benign radioresistant tumor that cannot be widely enough excised locally, in other words a tumor that is locally malignant owing to its anatomic location and not to its morphologic composition. The authors report 2 cases in which interscapulothoracic amputation was done. One was a case of metastatic carcinoma, and the other, of primary sarcoma. The patients have survived, one fifteen years and the other two years. Montant and Perrier [746] report a patient with metastasis of hypernephroma to the right humerus who had an inter-

743. Mohs, F. E.; Sevringhaus, E. L., and Schmidt, E. R.: Conservative Amputation of Gangrenous Parts by Chemosurgery, Ann. Surg. **114**:274-282 (Aug.) 1941.

744. Willis, D. A., and Teitelman, S. L.: Simplified Technic for Amputation Through Thigh, Surgery **10**:633-635 (Oct.) 1941.

745. Strode, J. E., and Fennel, E. A.: Treatment of Tumors of Shoulder Region by Interscapulothoracic Amputation, Surgery **9**:394-402 (March) 1941.

746. Montant, R., and Perrier, C.: Interscapulothoracic Disarticulation for Metastasis of Hypernephroma to Right Humerus: Secondary Nephrectomy, Rev. méd. de la Suisse Rom. **61**:170-175 (March 25) 1941.

scapulothoracic amputation performed and later survived a nephrectomy by which the tumor was identified. It is admitted that had this tumor been recognized before operation, the extensive amputation operation would not have been performed. Selig [747] gives the history of a patient on whom an interinnominoabdominal amputation was done for a Ewing tumor near the trochanter; the patient lived forty-five days after operation.

Artificial Limbs.—Five articles on artificial limbs describe such specialized points as the character of sockets, a pneumatic knee joint control arrangement admittedly noisy and lightness in weight. The Council on Physical Therapy of the American Medical Association [748] has a most excellent article discussing the industry itself, materials and construction. A new knee joint lock is mentioned which locks in extension when weight is borne on the heel and unlocks when weight is borne on the toe.

Braces.—As a by-product of the postoperative treatment of cup arthroplasties of the hip, Tobin [749] has assembled an anterior ring Thomas splint, with a Pearson attachment, which permits a good range of motion of both hip and knee while traction is being maintained.

Apparatus.—Two goniometers have been described. The one described by Cooper [750] incorporates a fixed horizontal limb, employing a level which facilitates the measuring of joint angles from the horizontal position. The one described by Molander [751] includes the use of charts on which ranges of motion are recorded for the various joints, rubber stamps being employed to represent the different parts. Both are of value in cases in which more detailed records than usual are needed.

Krusen [752] has devised a custom-built heating cup for applying uniform heat to the shoulder. This consists of a covering made of electrical conducting material similar to that employed in heating deep sea diving suits. The axillary space is covered as well as all other areas of the shoulder.

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747. Selig, S.: Interinnomino-Abdominal (Hindquarter) Amputation, J. Bone & Joint Surg. **23**:929-934 (Oct.) 1941.

748. Manufacture of Artificial Limbs, Council on Physical Therapy, J. A. M. A. **117**:1441-1445 (Oct. 25) 1941.

749. Tobin, W. J.: Splint to Increase Hip and Knee Motion, J. Bone & Joint Surg. **23**:712-713, (July) 1941.

750. Cooper, W.: Simplified Arthrometer, Ann. Surg. **114**:316-317 (Aug.) 1941.

751. Molander, C. O., and Weinmann, B.: New Chart System for Recording Joint Measurements, Physiotherapy Rev. **21**:88-90 (March-April) 1941.

752. Krusen, F. H.: New Conductive Heating Device to Provide Uniform Heating of Periarticular Structures of Shoulder Joint, Proc. Staff Meet., Mayo Clin. **16**:328-329 (May 21) 1941.

Schneider [753] describes an adjustable osteoclast which permits pressure to be applied with great accuracy and a minimum of trauma and which is arranged so that it can be radiographically controlled. The apparatus is complicated, and the interested reader is referred to the original article for further detailed information and illustrations.

A crutch of simple design which extends only to the elbow and obviates the possibility of crutch paralysis is described by zur Verth.[754] This idea is not new, but it is believed that if information on this type of crutch were more generally available, its use would be more widespread.

Surgical Instruments.—Lyon, Cochran and Smith [755] have written an article which should be read in the original by those using bone screws. Important experimental work is reported to substantiate the recommendations regarding the selection of the proper type of screw. Original determinations to ascertain the proper drill size for the screws tested are presented. The importance of using a screw with a coarse thread rather than one with a machine thread is emphasized. The tapering character of the usual wood screw is deprecated. [ED. NOTE: This is a most excellent article.]

The new, justly popular Luck electric bone saw and drill is described by its designer in an excellently written article.[756] Its various advantages, such as complete, easy sterilizability, light weight, key chuck and twin speed, are mentioned. [ED. NOTE: One of us (J. W. W.) has used this bone saw constantly for many months and finds that its claims are not overstated and that it can certainly be recommended.]

For the purpose of obtaining osteoperiosteal grafts of uniform thickness from the face of the tibia, Burns [757] has designed a chisel with a guard; this causes it to function as a plane and prevents the removal of more than a thickness of 3/16 inch (0.48 cm.) of the cortex. [ED. NOTE: One of us (J. W. W.) used this type of instrument several years ago and finally gave it up because most tibias are too hard and the cutting edge of the chisel would not continue to bite evenly but would jump out frequently.]

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753. Schneider, J.: Universal Osteoclast for Medical and Terminal Osteoclasis and Correction, Arch. f. orthop. u. Unfall-Chir. **40**:492-494, 1940.

754. zur Verth, M.: A New Type of Crutch, Jahresk. f. ärztl. Fortbild. **31**:16-17 (Dec.) 1940.

755. Lyon, W. F.; Cochran, J. R., and Smith, L.: Actual Holding Power of Various Screws in Bone, Ann. Surg. **114**:376-384 (Sept.) 1941.

756. Luck, J. V.: Electric Bone Saw and Drill, Am. J. Surg. **54**:505-507, (Nov.) 1941.

757. Burns, R. E.: Osteoperiosteal Chisel, J. Bone & Joint Surg. **23**:384-385 (April) 1941.

Plaster Cast Technic.—Many new publications on plaster cast technic have appeared. The most important is an English article by Creer,[758] who discusses in detail the making of a standard pattern of plaster-incorporated crinoline to assist in the rapid application of spica casts to the hip. Three different sections of the spica cast, namely, a posterior body piece, an anterior body piece and a leg piece, are made, each being seven or eight layers thick and of a size to fit the particular patient. When applied, there is ample overlap, and the entire cast is fixed with a few plaster bandages. Although this idea is not new, more detail is given in this article than usual, and its use should cut several minutes off the time employed for the application of a spica cast after an operation. [ED. NOTE: A thorough study of the original article is recommended.]

Sullivan [759] emphasizes once more the value of extensive cast immobilization in the treatment of wounds in the extremities, calling attention to the success of the Orr-Trueta method in cases in which this is the prime factor.

It is feared that except on board ship or in a clinic closely associated with a machine shop the admittedly advantageous knee action shock-absorbing walking iron for a plaster cast devised by a machinist's mate in the United States Navy, Ferrell,[760] would be seldom manufactured. The ordinary rubber-covered metal stirrup, while not as comfortable, takes less room than the de luxe one pictured in the original article. The apparatus consists of two springy weight-bearing surfaces attached to the bottom of a cast.

Internal Fixation.—Six worth while papers discussing the use of metals in the internal fixation of bone show that the issue is still a live one, but it looks as though vitallium products are gradually being supplanted by the less expensive, tougher and more generally usable stainless steel products.

Key [761] calls attention to the value of the 18-8 S-MO stainless steel, which appears after extensive tests to be as nonirritating as vitallium, and recommends that articles made from it be standardized by the Fracture Committee of the American College of Surgeons and be properly marked for the protection of the surgeon.

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758. Creer, W. S.: Standard Pattern for Hip Spica, Lancet **1**:9-10 (Jan. 4) 1941.

759. Sullivan, J. E.: Immobilization in Treatment of Wounds of Extremities, S. Clin. North America **21**:571-576 (April) 1941.

760. Ferrell, B. E.: Walking Appliance for Plaster Casts, U. S. Nav. M. Bull. **39**:413-415 (July) 1941.

761. Key, J. A.: Stainless Steel and Vitallium in Internal Fixation of Bone: Comparison, Arch. Surg. **43**:615-626 (Oct.) 1941.

Campbell, Meirowsky and Hyde [762] report on the toxicity of various alloys and metals, including ticonium (an alloy made up of nickel, cobalt, chromium and molybdenum, with a small amount of beryllium if it is to be cast), on fibroblast cultures. They have found that gold, silver, ticonium, vitallium and stainless steel are nontoxic while vanadium and copper are highly cytotoxic. [ED. NOTE: The authors unfortunately do not differentiate between the types of stainless steel, and this detracts considerably from the value of the article.]

Venable and Stuck [763] call attention to improvements in the strength and the flexibility of the new vitallium products made after the formula for vitallium was changed because the original metal was too brittle. They claim that the tensile strength of nails, screws or plates is unimportant. [ED. NOTE: This is a statement which is difficult to understand.] They advise the use of a wood or coach type of screw which does not taper except at its tip and suggest that the drill hole must be made the same size as the shank of the screw. [ED. NOTE: One of us (J. W. W.) believes that the size of the drill hole should vary with the density of the bone. In cancellous bone, a screw will hold much more securely if the drill hole is just small enough to allow the screw to be driven in with a reasonable amount of resistance but without the risk of twisting off the head.] The proper technic of inserting the screws is described, and the special need of proficiency in this exact and important type of craftsmanship is well stressed.

For internal fixation of fractures of the femoral neck Lorenzo [764] advocates the use of a rather complicated-looking lag screw arrangement requiring special but simple equipment for its insertion. Its particular merit seems to be that it produces positive pressure between the bone surfaces at the site of the fracture. [ED. NOTE: The chance that the bone surfaces may be held apart when the usual physiologic bone absorption at the fracture surface during repair occurs is not mentioned. Some of the author's illustrations which show the guide wire penetrating the floor of the acetabulum should be more carefully explained, as they certainly do not create a favorable impression. His advice to wait four or five days before fixation to allow shock to subside is open to question. It is the belief of most surgeons who employ hip nailing that early fixation is desirable to make the patient more comfortable

762. Campbell, E.; Meirowsky, A., and Hyde, G.: Studies on the Use of Metals in Surgery: Comparative Determinations of Cytotoxicity of Certain Metals (Including Ticonium) in Fibroblast Culture, Ann. Surg. **114**:472-479 (Sept.) 1941.

763. Venable, C. S., and Stuck, W. G.: Three Years' Experience with Vitallium in Bone Surgery, Ann. Surg. **114**:309-315 (Aug.) 1941.

764. Lorenzo, F. A.: Molybdenum Steel Lag Screw in Internal Fixation of Fractured Neck of Femur, Surg., Gynec. & Obst. **73**:99-104 (July) 1941.

as soon as possible. This type of injury, while it is ordinarily extremely painful, is not usually associated with shock.]

New Operations.—Albee [765] has reported an interesting bone-drilling operation devised for the treatment of chronic ulcers in the lower part of the leg. Healing of ulcers that have responded to nothing else is reported in two thirds of all cases. No infection was encountered although the drill passed through the infected ulcers into the medullary cavity. [ED. NOTE: One wonders whether the improved care and the lack of weight bearing might not have been a contributing factor. The idea presented certainly has a great deal of merit and is apparently safe.]

Speed [766] reports on using vitallium caps on animal and human radial heads to insure the return of rotation. The author hopes by using this method to shorten the convalescence after excision of radial heads and to avoid trouble with the distal radioulnar joint so common in cases in which excision of the radial head has been necessitated. [ED. NOTE: The subject is most interesting but as the author admits is in the experimental stage. Further reports will be awaited.]

As advocated so extensively by Bunnell, the use of silver wire as a suture in secondary wound closure is urged by Payr.[767] Attention is called to the fact that the wire itself is an antiseptic and that if conditions require a stitch may be released by untwisting a wire.

Koontz and Shackelford [768] in a series of experiments on dogs have demonstrated that alcohol-preserved fascia and living fascia give the same results when used as a bone suture. [ED. NOTE: This does not seem reasonable, and it is hoped that this work will be checked by other investigators. It appears to be at variance with generally accepted facts.]

Equalization of Length of Legs.—In an excellent article Moore [769] brings up to date the present status of leg-lengthening operations. He reviews critically the cases of 19 patients operated on in the last twelve years who have reached growth maturity. With regard to gait, only 6 are considered to have been improved; nine were not improved, and 4 were made definitely worse. The author considers that weak hip mus-

765. Albee, F. H.: Bone Drilling in Resistant Chronic Ulcers: New Principle, Am. J. Surg. **54**:605-608 (Dec.) 1941.

766. Speed, K.: Ferrule Caps (Vitallium) for Head of Radius, Surg., Gynec. & Obst. **73**:845-850 (Dec.) 1941.

767. Payr, E.: Advantages of Silver Wire Suture in Wound Closure Compared with Delayed or Secondary Suture and Plaster Strapping, Zentralbl. f. Chir. **67**:1958-1961 (Oct. 19) 1940.

768. Koontz, A. R., and Shackelford, R. T.: Comparative Results in Use of Living and Preserved Fascia as Suture Material in Bone, Surgery **9**:493-502 (April) 1941.

769. Moore, B. H.: Critical Appraisal of Leg Lengthening Operation, Am. J. Surg. **52**:415-423 (June) 1941.

cles and a weak quadriceps muscle account for most of the less satisfactory results. There were no cases of nonunion; infection of slight degree was observed in 1 case, and temporary nerve involvement was present in 2 cases. [ED. NOTE: This is an excellent summary of a hazardous surgical procedure that was at one time popular. It is well worth reading by the young enthusiastic surgeon contemplating a tibia-lengthening operation.]

Kofmann [770] has published a rather brief discussion of the various bone-shortening operations. He mentions various procedures, including his own autosynostosis operation, which consists of cutting a generous curved section apparently out of the lateral side of the shaft of the bone before transverse osteotomy across the shaft at the narrowest portion of this curve. He thus produces two pointed ends, one of which is slipped into the medullary cavity of the other. He emphasizes the simplicity of his technic and calls attention to the value of the shortening procedure in cases of finger contracture, manus vara, Volkmann's contracture and growth deformity. [ED. NOTE: The author unfortunately devotes little space to the details of the technic he has proposed.]

Harmon and Krigsten [771] discuss the surgical treatment of discrepancies of leg length. They emphasize the epiphysial arrest procedure on account of its simplicity, stressing, however, the need of accurate calculation, particularly as to which epiphysis is to be operated on and when during the period of growth the operation should be done. They sound a note also relative to the formidability of the leg-lengthening procedure which they consider much more hazardous than the shortening technic. They quote various authors who have studied the proportionate growth of the epiphyses of the lower extremities. They consider the growth to be approximately as follows: 12 per cent upper femoral; 40 per cent lower femoral; 28 per cent upper tibial, and 20 per cent lower tibial. [ED. NOTE: These figures seem reasonable and safe enough to be relied on in calculation. Exception might be taken to the statement that "leg shortening is the most exact and frequently indicated operation in . . . adolescence." After mature study one of us (J. W. W.) feels that during the adolescent growing period the growth arrest operation is the more certain, especially in view of the fact that the amount of growth stimulation associated with the shortening procedure is difficult to predict. Sometimes a net gain of only 50 per cent of the actual amount shortened can be finally recorded.]

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770. Kofmann, S.: Autosynostosis as Simple Method of Shortening the Bone, J. Bone & Joint Surg. **23**:159-161 (Jan.) 1941.

771. Harmon, P. H., and Krigsten, W. M.: Surgical Treatment of Leg Length Discrepancies, Illinois M. J. **79**:300-307 (April) 1941.

Two articles on the effect of roentgen irradiation on the epiphysis or, more accurately, the metaphysis [Ed. Note: This term does not yet seem to be in common usage.] appeared during 1941. Judy [772] reports that small doses of roentgen radiation to the metaphysis apparently do not stimulate growth. An unsuccessful attempt was made to retard growth of the long leg in a child by fractional roentgen doses. Sufficient retardation was produced in 4 children to result in the appearance of definite transverse growth lines, but not enough was obtained to be of any practical use. This paper is a preliminary report only, and further experimentation with larger doses is to be done on animals.

Spangler [773] reported also the cases of 4 children in whom early closure of the epiphysis was attempted by fractional roentgen doses without definite success. The author admits that the treatments were given with "fear and trembling" and that the subject is still decidedly in the experimental stage.

[Ed. Note: One of us (J. W. W.) was associated with Dr. Judy in his work. While it is believed definitely that sooner or later arrest of growth will be accomplished by roentgen irradiation, at present the factor of safety between serious soft tissue damage and effective exposure is too narrow. More definite information must be obtained by animal experimentation before further work on children can be attempted.]

XX. RESEARCH

Bone Growth, Repair and Metabolism.—A considerable amount of experimental work regarding bone growth, repair and metabolism has been reported in the literature of 1941. The subjects investigated cover a wide range of interest and are rather loosely connected. Therefore, no attempt will be made to indicate by a blanket statement the degree of progress attained in any one direction.

Vitamins and Bone Formation.—Roche and Marcelet [774] state that the long bones and the flat bones present a different sensitivity to the action of vitamin D on disturbed alimentary factors. Only the long bones calcify normally when the diet is unbalanced in the course of growth; the flat bones present a marked demineralization persisting even to adult life. On the contrary, an abundant intake of balanced salts permits the

772. Judy, W. S.: Attempt to Correct Asymmetry in Leg Length by Roentgen Irradiation: Preliminary Report, Am. J. Roentgenol. **46**:237-240 (Aug.) 1941.

773. Spangler, D.: Effect of X-Ray Therapy for Closure of Epiphyses (in Correction of Asymmetry in Leg Length): Preliminary Report, Radiology **37**: 310-315 (Sept.) 1941.

774. Roche, J., and Marcelet, Y.: Comparative Sensitivity of Long Bones and Flat Bones to Action of Vitamin D and to That of Alimentary Saline (Calcium and Phosphorus) Disequilibrium, Compt. rend. Soc. de biol. **134**:280-282, 1940.

organization of fundamental osseous tissue and of phosphocalcific reserves, even in the absence of vitamin D, in the long bones, while the important deposition of salts in the flat bones takes place only in the presence of vitamin D. It appears, therefore, that the long bones fix salts preferentially as compared with the flat bones. The fact that this tropism of the long bones is much more marked in young animals suggests the hypothesis that endochondral ossification participates more actively than membranous ossification; the great affinity of conjugating cartilage for salts seems to support this view.

The authors state that Sherman, Stiebeling and Fischmann have demonstrated that the role of vitamin D in ossification is important on the one hand because of its action in the absorption of salts carried by the diet and on the other hand because of its action in the organization of fundamental osseous tissue. The first action manifests itself equally in growing animals and in adult animals, while the second can be effective only before the growth of the skeleton is completed.

Mellanby [775] reports experiments with young dogs to determine the effect of vitamin A deficiency on the growth of bone. In previous publications he has presented evidence of the widespread degeneration of the central and the peripheral nervous system, especially in young animals brought up on diets deficient in vitamin A and carotene and rich in cereals.

All or nearly all bones in the body are affected by these vitamin A–deficient diets, but this report deals mainly with the gross changes in the bones of the skull and of the vertebral column and the effect which these changes have on the nervous system.

If the administration of the special diets is started when puppies are 6 to 9 weeks of age, the animals' incoordination of movement and other signs of abnormal behavior and appearance develop two to four months later, and after four months the abnormality may be great. In fully grown animals, on the other hand, although vitamin A deficiency affects bone structure, the action is slow, and many months or even a year or more may be required to produce noticeable changes.

A comparison of mesial sagittal surfaces of the skull of 2 litter mates, one of which had a diet containing much vitamin A and the other a diet deficient in the vitamin, shows some of the regions which are especially subject to overgrowth of bone. The bones showing the most overgrowth are those surrounding the cerebellum, the medulla oblongata and the pons varolii. In particular all parts of the occipital bone are greatly enlarged. Passing forward, the parietal bone is also much thickened in its posterior

775. Mellanby, E.: Skeletal Changes Affecting Nervous System Produced in Young Dogs by Diets Deficient in Vitamin A, J. Physiol. **99**:467-486 (June 30) 1941.

part, but this thickening becomes less as it approaches the frontal bone. The effect of this overgrowth is to press on the cerebellum and the medulla and alter their shape. The cerebellum is flattened on its dorsal surface, and its posterior surface is indented just above the foramen magnum. The medulla is similarly compressed, and the fourth ventricle and the aqueduct of Sylvius are narrowed and reduced in capacity.

The kind of differences observed in the shape and the texture of the bones of the skull of normal and vitamin A–deficient dogs can be seen also in the bones of the vertebral column. All the normally clearcut outline of the vertebrae disappears in the vitamin A–deficient animals. There seems to be little or no increase in the over-all dimensions of each vertebra, but all the processes, including the arches and the articular processes, are thickened to a greater or a lesser extent.

Gross sections of the femoral shafts were studied to determine the histologic changes occurring in vitamin A–deficient animals. There was a reduction in the diameter of the marrow cavity owing to an invasion of this cavity by cancellous bone.

The actual bone formed in the vitamin A–deficient animal is probably not far removed in character from normal bone. There is no demonstrable increase in osteoid tissue. It is the gross arrangement of the bone which is so strikingly changed. It is probable, therefore, that the main effect of vitamin A on bone growth is to control the activity and the number of osteoblasts and osteoclasts, primarily those associated with the bone marrow but also to a lesser degree the same cells in the subperiosteal region. In the absence of the vitamin these cells become more active, but the change seems to be one only in intensity of cell activity but not in the function of the cells.

In the presence of vitamin A deficiency chemical examinations show that there is practically no change in the actual amount of calcium in the bones but that there is an increase in the fat content of the bones. [Ed. Note: This is an extremely valuable and interesting study. It should stimulate further investigations in this field of research.]

Epiphyses and Bone Growth.—In investigations on epiphysial growth, Ingalls [776] has selected the tibial epiphysis of albino rats receiving an adequate diet of cereals, minerals and vitamins for study. A new method of taking roentgenograms of the knee with the tube directly over the joint and with the use of dental film has been found to give sharper details, especially when the bone is denuded of soft parts. Some bones were impregnated with silver; this gives sharp contrasts in the roentgenograms. The author describes a modification of the Goworsi method of preparation of tissue sections. The anatomy of the epiphysial plate

776. Ingalls, T. H.: Epiphyseal Growth: Normal Sequence of Events at Epiphyseal Plate, Endocrinology **29**:710-719 (Nov.) 1941.

is reviewed. The following factors influencing growth are mentioned: nutritional (calcium, phosphorus, vitamins D and C); endocrine (pituitary, thyroid, parathyroid, sex gland), and toxic (lead, phosphorus, bismuth, fluorine). Disturbances of any of these factors register changes within a few days at the epiphyses, and the diagnosis (e. g., scurvy, rickets, lead and phosphorus poisoning) can be made by the histologist and roentgenologist.

Ingalls summarizes briefly: The cartilage is composed of germinal, proliferating and degenerating layers. The metaphysis is composed of a rind of new bone laid down by osteoblasts around the calcified matrix of degenerated cartilage cells. In the interstices of the metaphysis are capillaries, osteoblasts and osteoclasts, developing and remodeling the true bone. Calcium depositions have been demonstrated in both the longitudinal and the transverse septums of the matrix of the degenerating cartilage cells. [ED. NOTE: Some authors have previously concluded that calcium salts are deposited only in the longitudinal septums.] The deposition of calcium salts in the ground substance appears to follow the death of the cartilage cells.

Ingalls and Hayes [777] have studied the effect of removal of adrenal and pituitary glands on the epiphysis of young rats. There was found to be an absence or inhibition of metaphysial bone formation. There was a decrease in the number of osteoblasts and in the amount of osteoid material present. These features are not the same as those recorded by some authors, namely, "features exactly analogous to those exhibited at the end of the normal growth period." The authors believe that there is widespread atrophy of the cartilage and the primary spongiosa and that there occurs halisteresis of the whole bone which is distinctly pathologic.

Banks and Compere [778] have performed experiments on rats and on rabbits to study the effect of injury to the epiphysial cartilage on bone growth and to confirm or disprove Selye's theory that "the growth of very young bones is largely independent both of the pituitary growth hormone and of the derivatives of epiphyseal cartilage anlage." Various gradations of damage were done to the epiphyses and the cartilage plates. The results of these investigations largely refute the theory of Selye. It was demonstrated: (1) that in resection of all or half of the epiphysis the resected portions are not restored and the longitudinal growth of the epiphysis is arrested and (2) that if the epiphysial cartilage plate is injured or resected the longitudinal growth of the shaft is either partly or completely arrested.

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777. Ingalls, T. H., and Hayes, D. R.: Epiphyseal Growth: Effect of Removal of Adrenal and Pituitary Glands on Growing Rats, Endocrinology **29**:720-724 (Nov.) 1941.

778. Banks, S. W., and Compere, E. L.: Regeneration of Epiphyseal Cartilage: Experimental Study, Ann. Surg. **114**:1076-1084 (Dec.) 1941.

Siegling [779] proves most conclusively that no growth in length of bone occurs from the epiphysial cartilage side of the epiphysis. Growth in the epiphysis takes place solely from endochondral ossification. This is substantiated by the concentric growth contours in the epiphyses of children who have had severe illnesses which seem to start at one end of the epiphysial line and end at the other. [ED. NOTE: This is an excellent article.]

Aries [780] states that textbooks of histology and embryology have to the present described longitudinal growth of bone as taking place by apposition at the diaphysial side of the epiphysial plate in the form of lines paralleling the epiphysial plate. Aries has given injections of alizarin red to 52 albino rats and killed them at intervals. The growth lines showed that longitudinal growth of long bones takes place in the form of superimposed serial cones within the diaphysial portion of the shaft, the bases of which are the epiphysial plate at any one given time. The periosteum deposits bone on the circumference of the shaft only and does not contribute to longitudinal growth. The distal end of the femur grows faster than the proximal end. The longitudinal growth and the growth in width follow a growth gradient which diminishes with age.

The irregularity in bone structure of rapidly growing epiphyses, particularly about the knee, seen in children in the early walking age is discussed by Sontag and Pyle.[781] They call this condition "disseminated calcification." The authors feel that it is influenced by thyroid function but give no satisfactory explanation to justify this belief. When it appears in other epiphyses during the second year of life or a little before, it is frequently considered unjustifiably as a pathologic process. It seems to be associated with early weight bearing. [ED. NOTE: Many who have seen this condition and have been somewhat at a loss to explain it will be enlightened by this article and especially by the statement that "it is a normal occurrence in rapidly developing epiphyses and indicates no pathology, being solely a maturational and growth factor."]

Stammel [782] describes two cases of multiple striae parallel to the epiphyses in the alae of the ilia. In the skulls of these patients the base appeared sclerotic; the bodies of the vertebrae were sharply outlined, and within the bodies were found contours of smaller well shaped bodies. In

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779. Siegling, J. A.: Growth of Epiphyses, J. Bone & Joint Surg. **23**:23-36 (Jan.) 1941.

780. Aries, L. J.: Experimental Analysis of Growth Pattern and Rates of Appositional and Longitudinal Growth in Rat Femur, Surg., Gynec. & Obst. **72**:679-689 (April) 1941.

781. Sontag, L. W., and Pyle, S. I.: Variations in Calcification Pattern in Epiphyses: Nature and Significance, Am. J. Roentgenol. **45**:50-54 (Jan.) 1941.

782. Stammel, C. A.: Multiple Striae Parallel to Epiphyses and Ring Shadows Around Bone Growth Centers, Am. J. Roentgenol. **46**:497-505 (Oct.) 1941.

the lower third of both femurs there was a definite fusiform swelling and many transverse bands parallel to the epiphysis. The head of the fibula showed similar striations. The scaphoid, the third cuneiform and the cuboid bone showed similar markings, but the other tarsal bones were negative. Both cases were similar in every respect except that in 1 there were striations of some of the teeth.

Stammel concludes that something occurred during the period of rapid growth of the bones involved that caused temporary delay or cessation of growth. The most probable condition that may cause this is unexplained periods of thyroid hypofunction. Repeated mild unrecognized attacks of scurvy may also be a plausible explanation. Also, it is possible that as children the patients may have ingested enough lead or other metal to be deposited in the bones but not enough to cause severe symptoms.

Lastly, it is not improbable that the condition may have been atypical mild undeveloped Albers-Schönberg disease, even though there was no tendency to fractures and no alteration in the blood picture in either case.

Ossification Centers.—Bruce [783] surveys the time and the order of appearance of ossification centers and their development in a series of embryonic rabbit skulls. The embryos were taken at intervals during gestation, beginning at sixteen days, two hours after copulation and extending to birth at thirty days. The method consisted of placing embryos after removal from the uterus in solution of potassium hydroxide long enough to soften the skin and the flesh. The writer states that if the embryo has been left in solution of potassium hydroxide for just the right length of time the skin becomes elastic and may be pulled off without injury to the bones. She concludes her study by observing that new ossification centers cover a period of twelve days from the sixteenth day, when the mandible appears, to the twenty-eighth day, when the petrous portion of the temporal complex starts to ossify. Ossification begins either in the central body of the bone, later spreading to the processes, or in processes which eventually grow together to form a central body. Those bones which develop in the latter way or those which develop no subsequent processes are the ones which acquire their characteristic shapes the earliest. A graph is presented showing the comparative time of appearance of ossification centers in several skulls in percentage of respective gestation periods. In animals having a shorter intrauterine period ossification occurs relatively later, and these animals are born at a relatively younger skeletal age. The order of appearance of the bones of the skull is about the same in rabbit, man, rat and mouse.

783. Bruce, J. A.: Time and Order of Appearance of Ossification Centers and Their Development in the Skull of the Rabbit, Am. J. Anat. **68**:41-67 (Jan.) 1941.

Mobilization of Bone Salts.—Walter, Van Slyke and Hufnagel [784] give a brief preliminary report on the effect of electrolysis in mobilizing and depositing calcium in an experimental animal. Two platinum bands each 2 mm. wide were wrapped subperiosteally around the femur of an anesthetized rabbit, the bands being about 1 cm. apart. Roentgenographic studies revealed transverse bands of decreased density underlying the region once occupied by the positive electrode. There was no gross reaction about the negative electrode. Control experiments showed that the electrodes themselves did not produce the changes described. It is believed that the response is dependent entirely on mobilization of the calcium from the bone.

The purpose of the experiments of McLean and Bloom [785] was to demonstrate histologically by a special technic the mobilization of bone salts and the relation of osteoclasts and other bone cells to this phenomenon. They conclude that the organic matrix of bone and bone salts are absorbed simultaneously by local cellular action and not by a phagocytic function of osteoclasts. There is no evidence from these studies that absorption of bone matrix occurs as a reaction to decalcification.

Delayed Ossification.—Cretin,[786] studying the histogenesis of osseous tissue in delayed consolidation, concludes: (1) that osseous construction is due to osteoblasts which receive their nutrition from muscle; (2) that for this reason it is impossible to separate the study of bone from that of muscle, and (3) that repeated hemorrhages about a fracture site which cannot be absorbed (perhaps in some instances owing to muscle injury) is a definite factor in producing delayed union. [ED. NOTE: This investigative evidence certainly has clinical value and may explain some cases of delayed union, especially in the shaft of the femur, where muscle usually completely surrounds the fracture site.]

Effect of Manganese on Bone Growth.—Studies were undertaken by Barnes, Sperling and Maynard [787] to determine whether any bone abnormality could be noted in the rat given a diet low in manganese. They have been unable to demonstrate any abnormal development of the tibia in the albino rat raised on a diet low in manganese provided the rat is normal at 21 days of age. The rat differs from the chick in being much

784. Walter, C. W.; Van Slyke, K. K., and Hufnagel, C.: Mobilization and Deposition of Calcium by Electrolysis: Preliminary Report, Surgery **10**:145-146 (July) 1941.

785. McLean, F. C., and Bloom, W.: Calcification and Ossification: Mobilization of Bone Salt by Parathyroid Extract, Arch. Path. **32**:315-333 (Sept.) 1941.

786. Cretin, A.: Histogenesis of Bone Tissue in Light of Study of Delayed Consolidation: Role of Muscles, Presse méd. **48**:996-999 (Dec. 11-14) 1940.

787. Barnes, L. L.; Sperling, G., and Maynard, L. A.: Bone Development in Albino Rat on Low Manganese Diet, Proc. Soc. Exper. Biol. & Med. **46**:562-565 (April) 1941.

less sensitive to a diet low in manganese. Only 2 cases of abnormal tibias occurred among a total of 16 rats born of females reared on a diet low in manganese. The limited data on rats from females reared on a diet low in manganese suggest that the growth of the female is impaired while that of the male is not.

Effect of Fluorides on the Skeleton.—Volker, Sognnaes and Bibby [788] have carried out a series of experiments on the biochemistry of fluorides, using radioactive fluorine. The blood fluoride level was found to decrease as the skeletal level rose, and the amount of rise paralleled the blood supply to that particular osseous structure.

Figures reveal that the greatest proportion of salivary and urinary fluoride was excreted during the first thirty minutes, i. e. the period when the blood level was highest. In discussing the results, the writers note that the high fluoride deposition in the bony skeleton is probably related to the observation that the addition of fluoride to the rachitogenic diet decreases the severity of experimental rickets.[789]

Endocrine Secretions and Their Effect on Growth, Maturation and Degeneration of Bone.—The effects of endocrine preparations on growth, maturation and degeneration of bone when administered to various experimental animals have been recorded during the past year. Some authors have attempted to explain mechanisms, and some have suggested possible correlation to human disease. Estrogen was shown in various experiments to increase phosphatase in the femur of the rat, increase serum calcium in ducks, increase bone formation in ducks, increase osteoblastic activity and increase bone ash. Solution of parathyroid in small repeated doses caused a temporary increase of phosphatase of the diaphysis and no change in the epiphysis of the rat. A large dose caused an increase which was followed by a decrease in the diaphysis and a decrease in the epiphysis of the rat. Solution of parathyroid did not have an effect on serum fat or bone formation in chicks. Extracts of adrenal cortex caused a decrease in phosphatase in the diaphysis and the epiphysis of the rat. Progesterone caused an increase in phosphatase in the femur of the rat. It promotes hyperplasia of cartilage and inhibits deposition of new bone and retrogressive changes in cartilage and bone. Testosterone propionate causes the os penis and ischial tuberosities to appear and develop faster in rats. Testosterone propionate accelerates growth, maturation and degeneration in female mice. Vitamin D presents visual or morphologic rickets, but if the criterion for judging the presence

788. Volker, J. F.; Sognnaes, R. F., and Bibby, B. G.: Distribution of Radioactive Fluoride in Bones and Teeth in Experimental Animals, Am. J. Physiol. **132**:707-712 (April) 1941.

789. Morgareidge, K., and Finn, S. B.: Effect of Fluorine on Activity of Vitamin D in Rachitic Rats, J. Nutrition **20**:75-84 (July) 1940.

of rickets is enlarged to include bone ash studies (in rats), phosphatase must be added to prevent rickets. Estrone (theelin) and its possible relation to osteitis fibrosa cystica are considered in this study.

Williams and Watson [790] carried out experiments to determine whether the sex hormones influence the phosphatase content of bone. Single large nonlethal doses were administered to albino rats of approximately 50 days of age. The animals were killed at intervals thereafter, and the phosphatase content of the femurs was analyzed.

The results may be summarized briefly as follows: Progesterone, testosterone propionate and estradiol benzoate tend to increase the phosphatase content, the effect being most marked in the epiphyses following use of testosterone propionate. Thymus extract causes a moderate increase, and the observations of others that thyroxin causes an increase in the phosphatase content of bone have been confirmed.

Williams and Watson [791] have attempted to explain the apparent salutary effects as well as the accompanying reduction of serum phosphatase following the administration of extracts of adrenal cortex to persons with Paget's disease of the bone and chronic arthritis. The possibility that there may be a modification in the production of the enzyme is the subject of the present investigation. Two types of experiments were performed; these were called the acute and the chronic type. In the former the effects of single large doses and in the latter the effects of small repeated doses of extract of adrenal cortex and solution of parathyroid on the phosphatase content of femurs of rats were determined.

The chronic experiments revealed that small repeated doses of solution of parathyroid produced a temporary increase in the phosphatase of the diaphyses without any change in that of the epiphyses. In the acute experiments this substance caused an increase followed by a decrease in the phosphatase of the diaphyses, while only a decrease in the phosphatase of the epiphyses was noted.

Extracts of adrenal cortex caused a reduction in the phosphatase of both diaphyses and epiphyses, the effect being more marked in the latter. Corticosterone and the compound E of Kendall (17-hydroxy, 11-dehydrocorticosterone), adrenal cortical substances, most closely approximated the effect of the whole cortical extract in reducing phosphatase contents of bones. No attempt is made to explain the mechanism underlying these changes, but there is thought to be a possible correlation

790. Williams, H. L., and Watson, E. M.: Influence of Hormones upon Phosphatase Content of Rat Femur: Effects of Adrenal Cortical Substance and Parathyroid Extract, Endocrinology **29**:258-261 (Aug.) 1941.

791. Williams, H. L., and Watson, E. M.: Effects of Adrenal Cortical Substances and Parathyroid Extract on Phosphatase Content of Rat Femurs, Endocrinology **29**:250-257 (Aug.) 1941.

between these findings and the results of the clinical use of extract of adrenal cortex in the treatment of Paget's disease.

The Silberbergs [792] have investigated the effect of progesterone on changes taking place in cartilage and bone during growth and aging. Seventy guinea pigs were used; these were given subcutaneous injections of progesterone on six days of the week for periods of one, two, four, six and eight weeks. Sections were made from the upper part of the tibia, the knee joint and the chondro-osseous junctions of several ribs.

Progesterone promotes slight hyperplasia of the cartilage cells which may be interpreted as a stimulating effect; however, at the same time it inhibits the deposition of new bone. Progesterone maintains the juvenile character of cartilage and bone by inhibiting retrogressive changes in the tissues. Progesterone inhibits the conversion of immature into mature bone, and in the ribs it inhibits atrophy, degeneration and calcification. These changes were almost the opposite of the acceleration of age changes following the use of estrogen.

In order to study more in detail the cellular changes which take place after administration of estrogen, Bremer [793] treated young white rats with theelin in varying amounts and over varying periods. The results noted were practically the same as those noted after the administration of solution of parathyroid.

The first histologic evidence of the beginning of osteitis fibrosa is the changing of osteoblasts from their normal shape to spindle cells and the uniting of neighboring cells by connecting strands, the whole forming a mesenchymal tissue. The changes are first noticeable on the peripheral bone spicules just beneath the inner cellular layer of the periosteum in the subepiphysial region and are accompanied by absorption of the newly formed bone and local increase of osteoclasts; this process spreads inward along the trabeculae. The same process takes place normally in growing long bones and leads to the molding and the shaping of the slender shafts beneath the wider broader articular ends. Normally the destruction of bone is strictly limited, taking place in an orderly manner along wide curves that sweep from the edge of the broad epiphysis to the surface of the narrower shaft, cutting diagonally across the tips of the newly formed bone trabeculae, which are oriented in a vertical direction following that of the vertical rows of cartilage cells in the epiphysial line. The extent of this process is governed by a true balance between estrogen and androgen, which are normally present in both male and female persons. These two principles are known to be

792. Silberberg, M., and Silberberg, R.: Effect of Progesterone (Corpus Luteum Hormone) on Growing Cartilage and Bone in Immature Guinea Pigs, Arch. Path. **31**:85-92 (Jan.) 1941.

793. Bremer, J. L.: Osteitis Fibrosa Localisata: Experimental Study, Arch. Path. **32**:200-210 (Aug.) 1941.

mutually antagonistic in their action. In rats treated with theelin the balance is disturbed, and the destruction becomes irregular and excessive. Osteitis fibrosa cystica is not due to an abnormal process but merely to an abnormal excess of a process which is itself normal in the molding of young bones.

In an attempt to reproduce in the bones of the rat conditions similar to those in the older normal chick, young white rats just weaned were treated with varying amounts of theelin for ten to twenty days and then allowed to live without injections for a further variable period. In a few rats significant changes were found. These consisted mainly of isolated areas of mesenchyme or cartilage in the subepiphysial region of the humerus. The author suggests that a true cyst might arise by the degeneration and central liquefaction of such an isolated mass or by the erosion of vessels and consequent hemorrhage.

An experiment was carried out by Turner, Lachmann and Hellbaum [794] in which castrated and uncastrated rats were treated by varying dosages of testosterone propionate. The results are reported as follows: Prolonged injections of testosterone propionate, even when begun one day after birth, did not significantly alter skeletal maturation or body growth in rats. The appearance of the os penis and the ischial tuberosity epiphyses were hastened. However, the osseous progress of untreated animals was such that at eighty-seven days there were no demonstrable skeletal differences between these and the treated rats.

The Silberbergs [795] distinguish three main phases of skeletal growth. In their strain C mice the first phase, lasting to the end of the fourth month, is characterized by proliferation of the epiphysial cartilage. The second phase, ending with the first year, is characterized by retrogressive changes in the epiphysial cartilage and an increase in density and thickness of the bones. The third period sees the ossification of the epiphysial cartilage and the resorption of bone in the shaft.

The time factor of these phases was used to study the influence of endocrine preparations on cartilage and bone growth. Anterior pituitary extract caused stimulation of cartilage proliferation; this was followed by shortening of the proliferative phase. With pituitary transplants an inhibitory effect is first noted, but this is followed by a prolongation of the proliferative phase. The processes of resorption of bone were more pronounced by the action of extracts; the formation of bone was more accentuated by the action of transplants.

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794. Turner, H. H.; Lachmann, E., and Hellbaum, A. A.: Effect of Testosterone Propionate (Androgen) on Bone Growth and Skeletal Maturation of Normal and Castrated Male Rats, Endocrinology **29**:425-429 (Sept.) 1941.

795. Silberberg, M., and Silberberg, R.: Effects of Hormones on Skeleton of Mice, Guinea Pigs and Rats, Endocrinology **29**:475-482 (Sept.) 1941.

In dogs, guinea pigs, rats and mice thyroid extract caused a marked stimulation of proliferation of cartilage; this was followed by a sharp decline and an intensification of processes of degeneration and resorption. Injections of potassium iodide caused the same reactions, but proliferation was less active and degeneration less marked. Injections of solution of parathyroid caused degeneration of cartilage without any preceding proliferative stimulation.

Estrogen and testosterone inhibit cartilage proliferation and temporarily the resorptive processes of cartilage and bone. Subsequently retrogressive changes occur more rapidly than normally. Estrogen is more active in both aspects than testosterone.

Gonadectomy and progesterone induce a primary delay of onset and progress of skeletal gain, but eventually in late stages this is neutralized by an intensification of the process of resorption. The effects of different endocrine principles on cartilage and bone vary in various species, in various strains in the same species and according to the age of the animal used.

Day and Follis [796] gave subcutaneous injections of estradiol benzoate at intervals varying from seventeen to one hundred and twenty-five days to more than 200 rats that ranged from 30 to 650 days of age. By means of histologic roentgen and chemical technics the effects of the estradiol benzoate on the skeleton were studied.

The histologic changes that were noted were mainly an increase at the growing ends of the bones. These changes were noted as early as seventeen days after the treatment was started. The skeletal changes were greater in female than in male rats. The authors' conclusions are that estrogen causes a decrease in normal destruction of bony trabeculae, just beneath the cartilage-shaft junction. At the cartilage-shaft junction they noted also an increase in osteoblastic activity. This was not noted at any other point. They conclude that this activity increases the density of the epiphyses and thus accounts for the increase in concentration of ash in the bone as a whole.

The Silberbergs,[797] in another study, used 36 virgin mice 2 to 4 weeks old. These mice received injections of testosterone propionate weekly for periods of two weeks, one month, two months, three months, four months, sixteen months and nineteen months. They found that in growing female mice the testosterone propionate accelerates the aging

796. Day, H. G., and Follis, R. H., Jr.: Skeletal Changes in Rats Receiving Estradiol Benzoate (Estrogen) as Indicated by Histological Studies and Determinations of Bone and Serum Calcium and Phosphate, Endocrinology **28**:83-93 (Jan.) 1941.

797. Silberberg, M., and Silberberg, R.: Response of Cartilage and Bone of Growing Mice to Testosterone and Propionate (Androgen), Arch. Path. **32**:85-95 (July) 1941.

of the epiphysial cartilage and that proliferation of the resting and columnar cells and their differentiation into hypertrophic cartilage cells and sclerosis, hyalinization and calcification of the cartilaginous matrix are intensified. The authors state that high single doses of testosterone administered over short periods are more effective in producing the changes than small doses over longer periods.

Lurie and Hertzman [798] report on the effect with regard to linear bone growth of the treatment with chorionic gonadotropin of undescended testicles and genital underdevelopment in 23 cases. They conclude that an average gain in height above the normal expectancy occurs in almost half of the cases. They do not feel that the preparation is dangerous to use since it apparently does not produce premature closure of the epiphyses or retard linear growth. [ED. NOTE: It is difficult to correlate this claim, however, with the warning given later in the paper that too prolonged treatment tends to advance the bone age.]

Muscles.—A review of the literature on muscles for the year 1941 reveals little of unusual significance aside from certain observations made on the subject of poliomyelitis. Apparently the muscular involvement in this disease is the result not only of a pathologic condition in the anterior horn cells but also of associated factors which contribute to loss of function. Most important of these is muscle spasm. This observation, emphasized by Sister Kenny and confirmed by observers at the Children's Hospital, Iowa City, may have an important bearing on the treatment of this disease.

The ineffectiveness of electric current in the treatment of experimentally induced muscular paralysis has been demonstrated. Further evidence has been produced that in lower animals transplanted muscles are unable to perform new functions and that the reflex activity of the muscle shows no alteration of activity. Crossing nerves to antagonistic muscles has no effect in modifying the inherent specific property of the nerve induced by the original muscle. The intravenous injection of potassium chloride appears to delay the onset of fatigue.

Vitamins and Muscular Dystrophy.—Muscular lesions have been observed by Krakower and Axtmayer [799] in rats given vitamin A–free diets to resemble those of muscular dystrophy due to a lack of vitamin E. Since vitamin A–free diets do not contain vitamin E, the authors have determined whether the muscular lesions are due to deficiency of vitamin

798. Lurie, L. A., and Hertzman, J.: Linear Growth and Epiphysial Closure: Effect of Treatment with Chorionic Gonadotropic Substance; Twenty-Three Cases, J. Clin. Endocrinol. **1**:717-725 (Sept.) 1941.

799. Krakower, C., and Axtmayer, J. H.: Effect of Alpha-Tocopherol on Lesions of Skeletal Muscles in Rats on Deficient Diets, Proc. Soc. Exper. Biol. & Med. **45**:583-586 (Nov.) 1940.

A or to lack of vitamin E. In one series of experiments they gave 17 young rats vitamin A–free diets. The mothers of these rats had been given vitamin A–free diets from the fourteenth day to the twenty-eighth postpartum day, when the rats were weaned. Eight of the 17 rats were fed 1.5 mg. of alpha tocopherol in olive oil weekly, the remaining 9 control rats were fed olive oil alone. A second series of rats, which were also weaned at twenty-eight days but whose mothers had been given a diet of Purina dog chow, were placed on a vitamin A–free diet. Eight were given weekly subcutaneous injections of 5 mg. of alpha tocopherol acetate, and the remaining 9 were left as controls. All animals either were killed or died, and histologic section was made. The authors found that muscular lesions hitherto described in connection with vitamin A deficiency in rats can be prevented by the administration of alpha tocopherol and hence are not related to the vitamin A–deficient state. Vitamin E or alpha tocopherol should form a part of the basal diet used to produce vitamin A deficiency in rats.

Neuromuscular Studies.—Sperry [800] studied the effect of crossing nerves to antagonistic muscles in the hindlimb of rats with particular regard to the phenomenon of modulation of nerve by muscle. Modulation is described by Weirs as follows: When a nerve is severed from its muscle and forced to regenerate into a foreign muscle, the nerve cells under the influence of the new muscle undergo a process of cell modulation, losing the specific properties induced by the original muscle and acquiring those specific to the new muscle. Various attempts at training all failed to induce reeducation. Postmortem examination and physiologic tests showed that nerve regeneration had been as intended and that sensory as well as motor fibers had reinnervated the muscles. Severance of the crossed nerves abolished the reversed movement. Control animals similarly operated on except that the nerves were reconnected to the original muscles showed foot movement in normal phase in all activities.

The right and left sciatic nerves of 11 dogs were severed by Molander and Steinitz [801] and immediately sutured; after this both hindlimbs were placed in casts. The gastrocnemius muscles of both legs were tested for ability to contract to the faradic and the galvanic current. Treatment was given to one leg, the other serving as a control, twice daily for six weeks with a current adjusted to just produce visible contractions.

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800. Spérry, R. W.: Effect of Crossing Nerves to Antagonistic Muscles in Hind Limb of Rat, J. Comp. Neurol. **75**:1-19 (Aug.) 1941.

801. Molander, C. O., and Steinitz, F. S.: Effect of Galvanic Current on Paralyzed Muscle: Experimental Study on Dog, Arch. Phys. Therapy **22**:154-160 (March) 1941.

Paralyzed muscles did not respond to the faradic current in any case. The treated muscles showed no less loss of weight than the others. In 6 of 9 cases there was slightly less pronounced histologic evidence of degeneration. The untreated muscles exhibited a greater responsiveness to the galvanic current than the treated muscles, but both became steadily less sensitive to stimulation as the experiment progressed. Histologic sections revealed no difference in the changes in the sciatic nerves of treated and untreated gastrocnemius muscles. There is no evidence that paralyzed limbs are benefited by electrical stimulation. It still remains to be demonstrated whether such benefits can occur in paralyzed limbs in cases of poliomyelitis.

Buchthal and Clemmesen [802] have determined the electrical behavior of the muscle by action potentials which represent innervation impulses but not the contractions themselves. In the resting, fully relaxed muscle no potential oscillations exist. When electromyograms were taken of muscles, in certain cases a permanent rest activity was found. The activity was of an intensity similar to that produced by moderate involuntary contractures. The peripheral sensory receptors were paralyzed by procaine hydrochloride injected subcutaneously; however, the rest activity remained unchanged. Intramuscular injections of procaine hydrochloride caused at first a decrease in the rest activity and then finally complete disappearance. The authors therefore believe that the phenomenon of rest activity is connected with the sensory receptors of the muscle.

In a series of 46 patients studied by means of electromyography in whom typical conditions affecting muscle and organic nervous disease were present, 8 patients showed rest activity. The authors believe that palpable conditions affecting muscle can be arranged in two groups by means of electromyography: the first group, in which the electromyogram is the same as that of a normal muscle; the second group, in which the electromyogram of the resting muscle shows permanently interfering action potentials which correspond to moderate muscle contraction. Intramuscular injections of procaine hydrochloride, quinine and calcium as well as intravenous injection of calcium stopped this rest activity. The authors interpret these results as indicative of a permanent irritation of the proprioreceptive receptors of the respective muscle, the cause of which is not yet known.

Weiss and Brown [803] have studied 20 cases (18 cases of poliomyelitis and 2 of spastic paralysis) by means of the electromyographic method in

802. Buchthal, F., and Clemmesen, S.: Differentiation of Palpable Muscle Affections by Electromyography, Acta med. Scandinav. **105**:48-66, 1940.

803. Weiss, P., and Brown, P. F.: Electromyographic Studies on Recoordination of Leg Movements in Poliomyelitis Patients with Transposed Tendons, Proc. Soc. Exper. Biol. & Med. **48**:284-287 (Oct.) 1941.

which transplantation of the biceps femoris to the extensor side of the knee joint was done. In their preoperative studies the authors observed that steady activity of the weak quadriceps muscle during flexor as well as extensor phases was present and seemed to be characteristic of coordination in patients with poliomyelitis in contrast to normal persons and patients with spastic paralysis. The biceps operates in the flexor phase only. Postoperative results indicated that when the leg operated on was removed from the cast for the first time no activity of the transplant was observed. Soon, however, the transplant began to show activity, at first in the flexor phase and after a few trials in the extensor phase as well. The transplant continues for some time to act in both flexor and extensor phases, and there is no evidence of automatic resumption of reciprocal innervation. After a further practice period of varying duration the transplant begins to be admitted during flexor actions. Relapses into the old flexor association may occur even years after the operation. These relapses seem to be favored by fatigue, lack of concentration and automaticity of movement. Their occurrence supports the view that the adjusted use of the transplant is not based on the substitution of a permanent extensor association for its former flexor association in the elementary motor mechanisms but rather on the development in higher centers of a new type of action which can effectively override the innate coordinative associations without abolishing them. This corroborates the distinction between lower, rigid and higher plastic systems in the control of coordination suggested by earlier observations.

Watrous and Olmsted [804] have studied the characteristics of reflex activity in a series of 5 dogs and cats in which various muscles were transplanted and present kymographic tracings to illustrate their findings. For example, the soleus muscle of a cat, an extensor, was transplanted to a flexor position. After decerebration typical exaggerated tone appeared in the soleus in spite of its flexor position and stimulation of the ipsilateral posterior tibial nerve caused inhibition of this tone. Similar studies were made after transplanting the peroneus longus muscle of a dog, a flexor muscle, to an extensor position.

The authors found that when tested by reflex activity the isolated responses of translocated muscles of the hindlimb of the adult cat and dog and of the translocated superior oblique muscle of the rabbit showed no alteration in function, even when as long as four months was allowed for readjustment.

[ED. NOTE: This work offers further evidence of the inability of transplanted muscles to perform new functions in the lower animals.]

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804. Watrous, W. G., and Olmsted, J. M. D.: Reflex Studies After Muscle Transplantation, Am. J. Physiol. **132**:607-611 (April) 1941.

Biochemical Studies of Muscles.—Hoff, Winkler and Smith [805] have studied the effect of the intravenous injection of potassium chloride on fatigued muscle. They have found that the normal marked reduction in the height of muscular twitches as recorded on a myograph after repeated stimulation of the muscle either directly or through its nerve supply is prevented by the slow intravenous injection of isotonic solution of potassium chloride. They suggest that since potassium is known to be liberated from muscles during the type of muscular activity described this may be a factor responsible for the decrease in the intensity of contractions in fatigue. They further suggest the hypothesis that the mechanism of the restoration of the vigor of contraction of fatigued muscle may consist in the replacing of potassium previously lost during the development of fatigue.

The efficiency of muscular work has been found to be increased if the work is interrupted by regular and short pauses of rest.

Certain aspects of previous experimental work with vitamin A are subject to severe critical reevaluation since it has been shown that the standard vitamin A–deficient diets are likewise deficient in vitamin E.

Further evidence is offered that muscle repair takes place by the growth of fibrous connective tissue.

Physiologic Studies of Muscles.—Maison and Broeker [806] have investigated the effect of muscle training on the increased capacity to perform voluntary work after daily use. They have studied the effect of removing the blood supply to a muscle on its muscle-training characteristics. An ergograph was attached to the middle phalanges of the middle and ring fingers so that the work of the extensor digitorum communis muscle could be accurately measured. A sphygmomanometer cuff was used to produce ischemia. The contralateral muscle work was measured with its blood supply intact as a control. The muscles were voluntarily worked to fatigue once each day.

Training patterns without blood supply showed small and slow gains in total work done. The work ability of muscle working without blood supply was not significantly increased by effective training with blood supply.

The authors conclude that muscle training is largely a phenomenon of improvement in nervous direction and vascular supply.

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805. Hoff, H. E.; Winkler, A. W., and Smith, P. K.: Recovery of Fatigued Muscle Following Intravenous Injection of Potassium Chloride, Am. J. Physiol. **131**:615-618 (Jan.) 1941.

806. Maison, G. L., and Broecker, A. G.: Training in Human Muscles Working With and Without Blood Supply, Am. J. Physiol. **132**:390-404 (March) 1941.

Simonson and Enzer [807] have studied the efficiency of lifting loads, interrupted by short rest pauses during which the subject was standing and was seated. Two subjects were studied; they were required to lift dumbbells of 4 to 6 Kg. a vertical distance of 1 meter with straight arms. Different variations of duration of each lifting and lowering with and without pauses between each lift were studied. The authors observed that the efficiency of muscular work was increased when the work was interrupted by regular and short pauses of one minute duration. This increase was still more pronounced if the subjects were allowed to sit during the interruptions. Similar results were obtained in 2 subjects at three different speeds and with two different loads.

Cartilage Growth and Metabolism.—The review of the literature for the year 1941 relative to cartilage, its growth, metabolism, respiration and regeneration reveals both clinical and experimental data. One of the more popular phases, as in years past, has been the cartilage graft, and several new points are brought to light regarding technical points in its use.

Dupertuis [808] presents a rather complete review of the literature on the subject of cartilage transplantation with divisions into experimental studies on fresh cartilage grafts in animals and experiments with preserved cartilage. Since he found no reports on actual growth in grafts, he set out to study this himself. His observations were as follows:

1. Autografts of young ear cartilage increased in length and surface area.

2. Isografts of young ear cartilage increased in size also, but to a lesser degree.

3. Isotransplants of adult ear cartilage into young rabbits showed no growth of the graft and were surrounded by scar tissue but did not decrease in size.

4. Autotransplants and isotransplants of rib cartilage into young rabbits increased in size in their transplanted sites but grew at a slower rate than ear cartilage; the autotransplant showed a greater increase in size than did the isotransplant.

5. Autotransplants and isotransplants of preserved young rib and ear cartilage in young animals all showed gross reduction in size with varying amounts of absorption; preserved cartilage grafts were entirely unsatisfactory.

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807. Simonson, E., and Enzer, N.: Effect of Short Rest Pauses in Standing and Sitting Position on Efficiency of Muscular Work, J. Indust. Hyg. & Toxicol. **23**: 106-111 (March) 1941.

808. Dupertuis, S. M.: Actual Growth of Young Cartilage Transplants in Rabbits: Experimental Studies, Arch. Surg. **43**:32-63 (July) 1941.

Young [809] reviews briefly the clinical and the experimental evidence regarding cartilage transplants of living and dead autogenous and homogeneous types. An experiment is reported in which 10 dogs were used. Autogenous living cartilage from the costal margins was transplanted into the abdominal wall. Half of these transplants had intact perichondrium, and the other half had the perichondrium removed. The grafts were examined grossly and microscopically over a period of two weeks to one and one-half years. The conclusion reached is that living autogenous cartilage grafts remain viable but do not change essentially their shape and size.

New and Erich [810] point out that freshly removed costal cartilage undergoes distortion by warping. This is most objectionable from the viewpoint of plastic operations. Preserved cartilage retains its shape because it has undergone the process of fixation. The statement is made that cartilage can be successfully transplanted from one person to another and that it may be preserved for an indefinite period in aqueous antiseptic solutions maintained at ice box temperatures. This permits the utilization of cartilage obtained post mortem. However, the authors prefer to use fresh autogenous cartilage.

Rosenthal, Bowie and Wagoner [811] present a complete report concerning the technical details of a method of study of the glycolytic activity of cells of bovine articular cartilage and the respiration of these cells. The material consisted of bovine articular cartilage obtained within one-half hour after slaughtering. The age of the animals ranged from 6 weeks to 11 years.

The authors' conclusions are as follows:

1. The cell count of bovine articular cartilage decreases by 75 per cent from infancy to old age.

2. The velocity of glycolysis remains proportional to the cell content of the tissue in all ages studied; thus the glycolytic power of the cartilage cells is not affected by aging.

3. The velocity of the oxygen consumption diminishes more rapidly than the cell content of the tissue; the respiratory power of adult cartilage cells is 30 per cent lower, and that of old cartilage cells is 60 per cent lower than that of young cells.

Joints Studied from the Physiologic and Histologic Points of View.—Little of value has been brought out in 1941 relating to the study of joints from the physiologic and histologic points of view.

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809. Young, F.: Autogenous Cartilage Grafts: Experimental Study, Surgery **10**:7-20 (July) 1941.

810. New, G. B., and Erich, J. B.: Method to Prevent Fresh Costal Cartilage Grafts from Warping, Am. J. Surg. **54**:435-438 (Nov.) 1941.

811. Rosenthal, O.; Bowie, M. A., and Wagoner, G.: Studies in Metabolism of Articular Cartilage, Respiration and Glycolysis of Cartilage in Relation to Its Age, J. Cell. & Comp. Physiol. **17**:221-233 (April) 1941.

Zeller, Bywaters and Bauer [812] have found that thiocyanate ions and dextrose diffuse readily into joint spaces of calves following intravenous injections. They used only 6 joints for their determinations of thiocyanate and only 2 joints for determinations of dextrose. Comparisons were made between other body fluids, but no significant conclusions were drawn.

King [813] finds that in Charcot's joints in addition to retrogressive changes there are well developed and easily recognizable progressive and proliferative changes in the synovial membrane. The author feels that the synovial fluid should be regarded as a fluid tissue rather than a secretion of the lining cells because: (1) it contains cells which are morphologically normal; (2) changes occur in the fluid which are most readily explained on the assumption that the fluid is under the definite cellular controls, and (3) in abnormal conditions, especially if the tissues are active, the synovial membrane may be shown to merge into the fluid.

Herrmann and Ruff [814] present an interesting differential diagnostic criterion between inflammatory and noninflammatory effusion in the joint. They found the tryptophan values varying from 23 to 333 mg. per hundred cubic centimeters. The lowest figures were found in cases of joint transudation of noninflammatory nature, particularly in those in which the condition was due to circulatory disturbances. Traumatic effusion due to various lesions showed a value between 40 and 88 mg. per hundred cubic centimeters. In cases of tabes the values were consistently around 68 mg. per hundred cubic centimeters with normal sedimentation time. Higher values were found in cases of syphilitic effusion (95 mg. per hundred cubic centimeters), in cases of effusion from intra-articular injection (111 mg. per hundred cubic centimeters) and in cases of syphilitic arthritis (119 mg. per hundred cubic centimeters). Tuberculosis showed a value between 131 and 178 mg. per hundred cubic centimeters. The highest figures were obtained in cases of infectious arthritis (100 to 333 mg. per hundred cubic centimeters). In all cases in which the tryptophan content exceeded 95 mg. per hundred cubic centimeters, the sedimentation rate was abnormally accelerated. The diagnostic value of the test lies especially in differentiating between active tuberculosis and traumatic conditions.

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812. Zeller, J. W.; Bywaters, E. G. L., and Bauer, W.: Passage of Thiocyanate and Glucose from Blood Stream into Joint Spaces, Am. J. Physiol. **132**:150-156 (Feb.) 1941.

813. King, E. S. J.: Synovial Membrane in Charcot's Joint, with Special Reference to Golgi Apparatus and Synovial Fluid, Arch. Path. **31**:693-701 (June) 1941.

814. Herrmann, H., and Ruff, W.: Determination of Amount of Tryptophan in Effusions as New Method for Their Differentiation, Wien. Arch. f. inn. Med. **34**:41-56, 1940.

Tendon and Muscle Repair.—In the literature of the past year relating to the mechanism and the rate of tendon repair several controversial points have been discussed. The source of granulation tissue necessary for this repair, the origin of tendon cells and the nature of these cells are treated. The mechanism of scar formation and its tensile strength are dealt with in another article.

Howard [815] has carried out a rather careful microscopic study of the tendons of human beings, mice and rats. The tendon cells are said to lie apposed in parallel rows with oval nuclei. These tendon cells lie between the closely packed parallel collagen fibrils and on close examination can be seen to enclose or line tiny canaliculi or longitudinal spaces. These tendon cells take the neutral red and show the characteristics of endothelial cells. One can refute the view held by some investigators in the past that they are the nuclei of a continuation of the muscle sarcolemmic sheath; the fact that they line spaces suggests that they are endothelial in origin.

Howard believes tendons heal primarily by granulation tissue derived from the surrounding paratenon structures and organized blood. These tendon cells as a specific type do not reform the tendon, but the developing scar tissue under stress lines up the developing collagen fibrils into parallel bundles.

Mason and Allen [816] have tested the return of tensile strength in dog tendons. The tendons were cut and immediately repaired by a special technic. The experiments were divided into two groups; in one the extremities were partially or completely immobilized, and in the other unrestricted motion was permitted. They find that three tissues take part in tendon repair, namely, the tendon itself, connective tissue in and on the surface of the tendon and the connective tissue surrounding the tendon.

The first stage in repair is the formation of a fibroblastic cuff about the injured area. This is completed about the fourteenth day. Organizing differentiation then begins. The intervening tissue assumes the strength and the appearance of tendon regardless of where its origin may have been. There are two phases of increase in tensile strength during the healing process of the injured tendon. The first phase lasts from the fifth to the sixteenth day, and the second phase begins from the nineteenth to the twenty-first day and continues for an undetermined period. Restricted use of the tendon after about the fourteenth day may

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815. Howard, N. J.: Pathological Changes Induced in Tendons Through Trauma and Their Accompanying Clinical Phenomena, Am. J. Surg. **51**:689-701 (March) 1941.

816. Mason, M. L., and Allen, H. S.: Rate of Healing of Tendons: Experimental Study of Tensile Strength, Ann. Surg. **113**:424-459 (March) 1941.

be expected to lead to an increase in the tensile strength of the union for the next one or two weeks.

A series of 72 experiments on dogs and rats was performed by Chouke and Whitehead [817] in an effort to find the characteristics of the healing which takes place when a muscle is severed and then sutured and also when fascia is severed and then sutured. The authors have found that healing of severed striated muscle of dogs and rats occurs by fibrous connective tissue growth from the epimysium, the perimysium and the endomysium and not through regeneration of muscle cells. Fascia unites readily to fascia when closely approximated by connective tissue growth. The type of suture material employed (silk or catgut) does not appear to influence the degree or the extent of union between fascia and muscle. The union of muscle to muscle and fascia to fascia is complete in eight to eleven days after suture.

817. Chouke, K. S., and Whitehead, R. W.: Wound Healing, with Especial Reference to Muscle and Fascia Repair, Surgery **9**:194-197 (Feb.) 1941.

REVIEW OF UROLOGIC SURGERY

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(Concluded from Page 1044)

BLADDER

Tumor.—McDonald, Doss and Thompson [30] feel that the diagnosis of sarcoma of the urinary bladder should be arrived at cautiously because of the possibility that a neoplasm of epithelial origin may be masquerading as one of mesodermal origin. They studied tumorous tissue obtained in 9 cases in which the diagnosis of sarcoma of the urinary bladder had been made, either with or without the coincidental presence of carcinoma, and were able to demonstrate the epithelial origin of all 9 tumors. McDonald, Doss and Thompson also were able to show that the carcinoma cells had assumed characteristics which, if examined histologically, were diagnostic of sarcoma. The short clinical history and poor results (all patients died of the disease, and only 1 lived longer than a year after the neoplasm had been first recognized) attest to the extremely malignant nature of all lesions of this type in the urinary bladder.

30. McDonald, J. R.; Doss, A. K., and Thompson, G. J.: Carcinoma of the Urinary Bladder Imitating Sarcoma, J. Urol. **46**:38-51 (July) 1941.

Herbst [31] reports on 124 patients suffering from carcinoma of the bladder seen at the Surgical Clinic in Vienna. In 64 cases necropsy was done. Most of the patients were seen in the late stages of the disease, about six months after the onset of symptoms. There was no connection between the size or the situation of the tumor and the duration of symptoms. Herbst believes that tumors situated in the trigone do not cause symptoms any earlier than do tumors found in other parts of the bladder.

Herbst discusses two types of carcinoma: the ulcer and the solid protruding tumor. In an occasional case a tumor of the bladder may be the result of metastasis from a neoplasm situated in other organs. Herbst reports having seen 1 patient who had a tumor of the bladder which was secondary to a tumor of the lung and 1 who had a tumor of the bladder which was secondary to a tumor of the gallbladder.

Results of treatment of this series of patients were bad. Therapy with radium and roentgen rays offered little. In Herbst's cases, partial resection of the bladder permitted cure in 10 to 20 per cent of the cases.

Baker and Brewer [32] report a case of endometriosis of the bladder. The patient was a woman 33 years old who had frequency of urination for four years. Cystoscopic examination revealed a circumscribed red lesion on the left posterior wall of the bladder. Later, she had stabbing suprapubic pain in addition to frequency of urination. This pain was cyclic, occurring every two or three weeks, and was accompanied by "drawing" pains in the breast. On pelvic examination a tender mass was found associated with the wall of the bladder and separate from the cervical stump. Several months later cystoscopic examination showed a puckering in the region of the bladder. At operation a mass was found and removed from the wall of the bladder. Microscopic examination disclosed endometriosis.

Müller [33] reports a case in which a tumor of the bladder developed in a worker in the aniline dye industry. A small papilloma extended up into the left ureter, causing obstruction, pronounced hematuria and complete destruction of the kidney. Müller, who has had varied experience in the treatment of tumors among workers with aniline dyes, discusses the different theories concerning the occurrence of these tumors.

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31. Herbst, R.: Zur Klinik und Therapie des Blasenkarzinoms, Ztschr. f. Urol. **34**:361-389, 1940.

32. Baker, W. J., and Brewer, J. I.: Endometriosis of the Urinary Bladder: Report of a Case, Tr. Am. A. Genito-Urin. Surgeons **34**:135-143, 1941.

33. Müller, A.: Bemerkungen zur Pathogenese der Anilintumoren. Mitteilung eines Falles von Ureterpapillom nach Benzidinschädigung, Schweiz. med. Wchnschr. **70**:232-233 (March 16) 1940.

Segal and Fink [34] report a case in which a cavernous hemangioma occurred in the bladder of a boy of 15 years. Cystoscopic examination revealed a mass the size of a small plum on the posterior wall of the bladder. Partial cystectomy was carried out, and histologic examination showed the tumor to be a cavernous hemangioma.

Segal and Fink state that about 40 cases of this condition have been reported. In 14 of these the patients were less than 20 years of age. Many surgical procedures have been employed, such as fulguration, local excision or radical resection by the open operation. Cures were described in 22 instances, with periods of postoperative observation ranging from several months to five years. Recurrence was noted in 4 of the reports of cases.

Conway and Broders [35] report a study of submucous extension of squamous cell epithelioma of the urinary bladder. A series of more than 400 specimens of tumor of the bladder removed surgically and 150 specimens of tumor of the bladder removed at necropsy was inspected. Forty of these, which when measured in the fixed contracted state presented a margin of 1 cm. or more of tissue apparently free of tumor on from one to four sides of the primary neoplasm, were chosen for study. When possible, each specimen was sectioned for microscopic study in each of four quadrants at distances of 1, 2 and 3 cm. or more from the perimeter of the primary lesion until tissue free of tumor cells was encountered or until tissue for further study was not available. Records of the patients from whom these tumors had been removed were analyzed, and the following conclusions were drawn:

It is impossible to determine how far malignant tissue extends laterally in the submucosa of the urinary bladder by gross observation at the time of operation. If segments of the bladder are to be removed at all, they should be removed only (1) when roentgen examination of the thorax reveals no abnormality which could be interpreted as metastasis, (2) when preoperative information derived from cystoscopic examination, cystography and intravenous urography indicates that the lesion is still confined to the bladder and (3) when thorough surgical exploration of the liver, the peritoneum and the regional lymph nodes reveals no abnormality which is suggestive of metastasis.

If segments of the bladder are to be removed the edges of the resected tissue should be examined microscopically before the operation is completed, to enable the surgeon to determine whether or not resection has been wide enough. If not, tissue should be removed until tissue free

34. Segal, A. D., and Fink, H.: Cavernous Hemangioma of the Bladder, J. Urol. **47**:453-460 (April) 1942.

35. Conway, J. F., and Broders, A. C.: Submucous Extension of Squamous Cell Epithelioma of the Urinary Bladder, J. Urol. **47**:461-471 (April) 1942.

of tumor cells has been encountered on all sides of the lesion, if possible. If this is not possible, as Conway and Broders believe is frequently the case, the operation is of prognostic value only, since, because of the problem of disposition of the ureters at such a stage in the operative procedure, the ideal time for total cystectomy will have passed.

Total cystectomy, with the same reservations outlined previously for segmental resection, is the rational method of treatment from the outset for cure of epitheliomas of the higher grades, for several reasons. One is the frequency with which squamous cell epitheliomas extend widely in a lateral direction in the submucosal coat of the bladder. Another is the not uncommon finding of carcinoma in situ in a bladder which already presents a fully developed malignant lesion. Another is the modest results obtained by the present generally accepted methods of dealing with malignant lesions of the bladder, and still another is the impracticability of performing total cystectomy after the bladder has been opened with some other procedure in mind.

Rupture.—Brunner and Kübler,[36] in a report on 25 patients suffering from rupture of the bladder observed in the Surgical Clinic in Zurich, Switzerland, discuss in detail the symptoms, the diagnosis and the therapy of this condition. In 17 cases the rupture was due to blunt trauma; in 8 cases the rupture was intraperitoneal, and in 9 it was extraperitoneal. In the remaining cases, rupture in 2 was secondary to gunshot wounds; in 3 it followed instrumentation, and in 3 it resulted from blows from various tools. Cases of accidental trauma of the bladder after operative procedures were not considered. The authors said that if they are discovered at once these operative accidents rarely cause trouble.

In only 1 case of intraperitoneal rupture of the bladder was there an associated fracture of the pelvis, and in none of the cases was there associated traumatism of other abdominal organs. The prognosis which accompanies intraperitoneal rupture is better than that which accompanies extraperitoneal rupture, because of the fact that in most cases extraperitoneal rupture is associated with heavy injuries. Only 2 patients suffering from extraperitoneal rupture were saved by operation. Introduction of catheters, use of lavage of the bladder, cystoscopy and urography are unreliable and misleading; accurate estimation of the output of urine and of the value for nitrogen in blood urea usually provides diagnostic aid. An increase in the value for nitrogen in blood urea suggests resorption of urine. When patients

36. Brunner, W., and Kübler, H.: Unsere Erfahrungen und Ergebnisse bei traumatischen Rupturen der Harnblase, Schweiz. med. Wchnschr. **70**:928-932 (Sept. 28) 1940.

who have this type of rupture are seen late the danger of infection is less than the danger arising from uremia by resorption.

Lipow and Vogel [37] report a case of spontaneous rupture of the bladder. They state that extraperitoneal rupture of the bladder usually is associated with trauma, inasmuch as the bladder is fairly well protected by fascial coverings and bony structure, whereas intraperitoneal rupture often is not associated with trauma. The bladder usually ruptures at a previously ulcerated portion or through a wall that has been long subjected to pressure from urinary obstruction. In the cases reviewed the amount of urine found in the abdominal cavity varied from 2,500 to 4,000 cc. In Lipow and Vogel's case more than 6,000 cc. was removed.

Causative factors concerned in rupture of the bladder are numerous. Generally speaking, the pathologic processes known to affect the bladder itself and its contiguous structures are the most ordinary agents in the production of rupture. Stricture, both organic and spasmodic, is one of the most common causes. Drunkenness was a feature in 7 cases. Tumors of the bladder or in the wall of the bladder and of the neighboring structures predispose to rupture. This is also true of prostatic hypertrophy. Tuberculosis of the urogenital system, particularly of the wall of the bladder itself, and generalized systemic tuberculosis have been reported and believed to form an important causative factor. Childbearing, interference with the nerve supply of the wall of the bladder and actual fatty degeneration all have been presumed to be of some etiologic significance.

In case of intraperitoneal rupture there is usually sudden severe abdominal pain, which the patient may not be able to localize in any particular part of the abdomen. This pain usually will be described as a sensation of "something having given way." The patient when first seen may be in a state of shock which varies from mild to severe, depending on the time that has elapsed from the beginning of his symptoms. The abdomen is distended, rigid and tender, and a fluid wave is present. There is a definite sensation of fulness in the flanks. Injection of a radiopaque substance into the bladder may disclose a rent of the organ. In rupture of viscera other than the bladder active motion of the patient is attended by severe pain and discomfort, owing to the fact that the highly irritating contents of the viscus have caused acute peritonitis.

Ulcer.—Suter [38] reports a series of 11 cases of encrusted ulcer of the bladder. Five of these cases were reported in detail. All the

37. Lipow, E. G., and Vogel, J.: Spontaneous Rupture of the Bladder, J. Urol. **47**:277-282 (March) 1942.

38. Suter, F.: Ueber das Ulcus incrustatum vesica, Schweiz. med. Wchnschr. **71**:1326-1329 (Oct. 25) 1941.

patients gave a history of trauma to the bladder, either mechanical or due to infection. There was usually a superimposed infection caused by some urea-splitting organism. Surgical treatment was used in all cases. Resection of the diseased portion, followed by fulguration, usually was done.

Interstitial Cystitis.—Pool and Crenshaw [39] report on the use of a solution of silver nitrate in the treatment of 34 patients who had interstitial cystitis. All the patients, excepting those concerning whom the diagnosis of interstitial cystitis had not been definite, responded to the treatment. The method of treatment used was to begin with a very dilute solution (1:5,000) and to increase the strength daily until a solution of 1 per cent was reached. The patient's bladder was thoroughly lavaged with the solution, and then 2 fluidounces (59 cc.) of it was allowed to remain in the bladder for five minutes. At the end of this time the bladder was emptied by means of a catheter. Although Pool and Crenshaw do not claim to have cured the patients, they do say that at the time of their report some patients had been free of symptoms for as long as six months.

Fibrosis of Vesical Neck.—Fister [40] reports a case in which submucous calcification of the vesical neck occurred in a boy 13 years old. He emphasizes the importance of the fact that although the patient had neurogenic incontinence there were neither roentgen evidences nor physical observations to indicate that any large amount of residual urine was present until calcification developed with obstruction of the vesical neck. The calcification was an acquired condition and developed during the time the patient was between the ages of 8 and 13 years. Fister states that fibrosis of the vesical sac was a progressive disease which preceded calcification. Fibrosis did not appear to have been incidental to muscular hypertrophy, since there was no hypertrophy of the trigone, the wall of the bladder or the internal vesical sphincter muscle. It may have been initiated by a disturbance of innervation of the sphincter muscle, followed by an acquired infection.

The patient had gained control of the bowels at the age of 7 years, and Fister expresses the belief that if fibrosis with calcification of the vesical neck had not occurred he most likely would have gained some control of the bladder without the aid of surgical intervention.

In the tissue removed from the orifice of the bladder was a dense proliferation of fibrous tissue with degeneration of muscle and connective tissue and deposits of calcium in the submucosa. Fister is of

39. Pool, T. L., and Crenshaw, J. L.: Treatment of Interstitial Cystitis with Silver Nitrate, Proc. Staff Meet., Mayo Clin. **16**:718-720 (Nov. 5) 1941.

40. Fister, G. M.: Fibrosis and Submucous Calcification of the Vesical Neck, J. A. M. A. **118**:604-608 (Feb. 21) 1942.

the opinion that calcification of the submucosa suggests some similarity to the calcification which occurs in Mönckeberg's disease of the blood vessels, in which atrophy of the muscle elements and deposition of calcium occur.

Similar calcification also is found in tissues affected by tuberculosis that have undergone fatty degeneration, but Fister's patient displayed neither clinical nor pathologic evidence of tuberculosis. It is Fister's belief that the submucous calcification also suggested some similarity to so-called exogenous prostatic calculi. But the patient's prostate gland was immature, and in the section of tissue removed from the vesical neck no calcification could be seen in the prostatic tissue. There was found no suggestion of a diverticulum of the prostatic urethra in which the stones might have developed. Disease of the parathyroid glands as a causative factor in the calcification was considered, but there was no clinical evidence that such a disturbance was present.

Prolapse.—Macpherson [41] reports a case of ureterocele in which prolapse through the external urinary meatus of a woman had occurred. When the labia were separated a bright red tumor was seen projecting through and beyond the external urethral orifice. It had an appearance which was suggestive of a polyp. When distended with urine, it was 2 inches (5 cm.) long and 1 inch (2.5 cm.) in diameter but could be extruded farther by traction. Reduction was simple; first, the sac was emptied and then pressed upward and backward against the external urethral orifice. The ureterocele then slipped back and as it did imparted much the same sensation as that which the physician notices in the reduction of a hernia. When the patient strained, the ureterocele could be prolapsed at will outside the external urinary meatus.

At operation the patient was asked to micturate. As she complied, the ureterocele presented outside the external urinary meatus. A fine ureteral catheter was then inserted into the ureteral orifice and cut down on for a distance of 1½ inch (roughly, 4 cm.) with an electrode. The diathermy cutting current was utilized, and the cyst was laid open. A finger was then inserted into the wound in the ureterocele, as a physician would insert a finger into a hernial sac to put it on the stretch, so to speak, and a circular section of tissue was excised. A week later cystoscopic examination disclosed that the inflated wall of the ureterocele had completely collapsed. Through a central opening, corresponding to the portion excised at operation, the dilated lower end of the ureter could be seen at the point at which it entered the bladder. The redundant wall of the ureterocele arose circularly around the ureteral orifice and was thrown into fairly firm, puckered folds. At this time

41. Macpherson, I.: Ureterocele, with Prolapse Through the External Urinary Meatus, Brit. J. Surg. **29**:294-298 (Jan.) 1942.

a right-sided ureterocele was found, which until then had been completely obscured by the one first seen, on the opposite side. The ureteral orifice was not visible. At the second operation, a diathermy electrode was passed through the cystoscope and the wall of the ureterocele on the right was split in a vertical direction by the cutting current throughout its whole length. Later, cystoscopic examination revealed both ureteral orifices. The left one was situated near the center of a slightly elevated circular portion of healthy mucosa. The right one could be seen at the base of a hoodlike projection of elevated translucent mucosa which had been slit vertically and had not contracted. There was no obstruction of either ureteral orifice, and the neighboring vesical mucosa presented a normal appearance. On the basis of the mode of onset and the disappearance of the symptoms in this case, Macpherson believes that a moderately large ureterocele can be present without causing any symptoms. The symptoms of his patients began suddenly and progressed without remission, and the onset of them seemed to date from the time the ureterocele on the left became large enough to reach the internal meatus and to cause obstruction to micturition. All symptoms were relieved by removal of the obstruction in the left ureter. Macpherson suggested that in this case the ureterocele did not represent prolapse of the lower end of the ureter as a whole, but prolapse and ballooning of only the mucous lining of the ureter.

PROSTATE GLAND

Hypertrophy.—Emmett [42] is of the impression that many patients suffering from the "tabetic type" of cord bladder can be helped by transurethral resection of the vesical neck. He reports a case to illustrate his view. The patient was a man 66 years of age who had found it necessary to wear a urinal bag for fifteen years and in whom complete urinary obstruction had developed, requiring catheterization three weeks before his admission to the hospital. Although only 8 Gm. of tissue was removed, the patient was able to void a normal stream of urine, to empty his bladder completely and to go through the night with only an occasional rising to void. Emmett believes that a bladder weakened by distention resulting from impairment of the sensory nerves which supply the bladder is more easily obstructed than is a normal bladder.

Kretschmer [43] discusses the end results of removal of obstruction of the neck of the bladder on the basis of study of the presence or the

42. Emmett, J. L.: Urinary Incontinence of Fifteen Years' Duration in a Tabetic Patient Relieved by Transurethral Resection: Report of a Case, Proc. Staff Meet., Mayo Clin. **16**:728-730 (Nov. 12) 1941.

43. Kretschmer, H. L.: End Results in Removal of Bladder Neck Obstruction, J. A. M. A. **119**:336-337 (May 23) 1942.

absence of residual urine in 144 cases in which prostatic resection had been done. This study revealed several interesting facts:

1. A definite increase in the percentage of patients who had no residual urine was noted; that is, this percentage increased from 66.3 in the first series to 78.47 in the third series of cases studied.

2. There was a reduction in the percentage of those patients who had 11 to 20 cc. of residual urine. This percentage was reduced from 16.11 in the first series to 13.88 in the third series.

3. A definite increase in the sum total of these two groups was recorded; that is to say, this sum total was 82.41 per cent in the first series, 87.90 per cent in the second series and 92.36 per cent in the third series.

4. There was a pronounced reduction in the percentage of patients who had from 21 to 30 cc. of residual urine. This percentage was 6.22 in the first series, 6.95 in the second series and 2.77 in the third series.

5. A decided reduction in the percentage of patients who had from 31 to 40 cc. of residual urine occurred; it decreased from 1.83 in the first series to 0.694 in this series.

6. There was a reduction in percentage of patients who had 41 to 50 cc. of residual urine, namely, from 2.19 to 0.694.

7. A definite reduction in the percentage of patients who had more than 50 cc. of residual urine was noted; it decreased from 7.32 in the first series to 3.47 in the final series.

Lich [44] investigated renal dysfunction in cases of prostatic obstruction by the use of simultaneous tests of the clearance of insulin and phenol red. He states that renal dysfunction in the presence of prostatism is primarily dysfunction of the tubules. The disturbed renal function in prostatism is definitely improved by continuous vesical drainage. Renal damage caused by prostatism is partially reversible, he states. Reestablishment of renal function is not complete, but reaches a peak beyond which no further functional improvement occurs.

Carcinoma.—Thompson [45] says that carcinoma of the prostate gland which has developed sufficiently to cause urinary obstruction cannot be completely eradicated by a surgical procedure, because it has already spread through the perineural lymphatic vessels. He believes that adequate transurethral resection, with removal of all the obstructing

44. Lich, R., Jr.: Renal Dysfunction in Prostatism, Surg., Gynec. & Obst. **74**:475-478 (Feb. 16) 1942.

45. Thompson, G. J.: Carcinoma of the Prostate: Its Conservative Surgical Treatment, South. Surgeon **10**:271-278 (April) 1941.

tissue, and the subsequent employment of high voltage roentgen therapy offer the patient the best prognosis. He also believes that the almost negligible risk of the operation (less than 1 per cent in 253 cases) and the almost certain assurance of perfect control of micturition postoperatively are strong arguments in favor of transurethral resection.

Barringer [46] states that authenticated five year cures of prostatic carcinoma are rare. He thinks that so-called aspiration biopsy is a valuable means by which to make an early diagnosis in about 50 per cent of the cases.

At Memorial Hospital for the Treatment of Cancer and Allied Diseases, New York, according to Barringer, there have been two general lines of treatment: (1) radiation therapy with radon needles or seeds applied perineally or suprapubically and (2) minimization of operative intervention. Of 352 patients, 36 (10 per cent) lived for more than five years. Of these 36, 15 died of carcinoma between the fifth and the tenth year, so that there remained 21, or 6 per cent, apparently free of carcinoma for periods of between five and nineteen years. High voltage roentgen therapy has been of little use in control of this disease. Radiation treatment is of great value in maintenance of patency of the urethra, he says, and in enabling a patient to empty his bladder throughout the years of life remaining to him. This applies to the small carcinomas confined to the prostatic and immediate periprostatic areas. Castration carried out by either surgical operation or roentgen rays may prove a factor in control of this disease. It should not be used to the exclusion of other methods.

Tuberculosis.—Strom and Thompson [47] report a case in which a patient came to necropsy. They believe the disease present represented true primary prostatic tuberculosis of the genital tract. Routine gross and microscopic examination did not reveal any evidence of tuberculosis elsewhere in the body. A small purulent abscess 4 mm. in diameter was found in the left lateral lobe of the prostate gland. This abscess had the typical histologic structure of tissue affected by tuberculosis and contained acid-fast organisms. Microscopic sections of the posterior urethra, the seminal vesicles, the vasa, the epididymes and the testes exhibited no pathologic changes. Strom and Thompson are certain that the prostate gland contained the only tuberculous lesion in the genital tract and possibly in the patient's entire body. This case was said to constitute further evidence against the old teaching that genital tuberculosis in the male subject always is initiated in the epididymes.

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46. Barringer, B. S.: Prostatic Carcinoma, J. Urol. **47**:306-310 (March) 1942.

47. Strom, G. W., and Thompson, G. J.: Primary Tuberculosis of the Prostate: Report of Case, J. Urol. **45**:858-862 (June) 1941.

TESTICLE, EPIDIDYMIS AND VAS DEFERENS

Tumor of Testicle.—Adams [48] reviews 21 cases of malignant testicular neoplasm from a pathologic standpoint. Study of this material lends support, he thinks, to the theory that these tumors, including seminomas and chorionepitheliomas, probably have a common origin. It has been held that they arise from a spermatogenic cell or cells. Such cells may be pleuripotential and give rise to tridermal metastasis. A case in which there were single tridermal metastatic processes, each process containing derivatives of all three germ layers, was cited as evidence for such occurrence. Adams suggested that trophoblastic tissue is present in teratoma testis more often than is commonly supposed and that its presence accounts for the appearance of large amounts of gonadotropic hormone in the urine of patients who have such tumors. The occurrence of hypertension in association with the excretion of large amounts of gonadotropic hormone in the urine was noted.

Hamilton and Gilbert [49] state that among men who have one testicular cancer, the likelihood of the development of cancer in the second testis is from several hundred to several thousand times greater than would be expected on the basis of chance association. Abdominally retained testes are especially susceptible to bilateral cancer. One of every 8 men who had bilateral testicular cancer also had abdominally retained testes, the authors state, a condition which can be estimated to occur in probably much less than 0.005 per cent of men. The pronounced carcinogenic tendency of abdominal testes also can be ascertained differently. Hamilton and Gilbert say that although the incidence of cancer in the presence of inguinal testes is high, the occurrence of cancer in abdominal testes is some fifty times higher, as is seen by comparison with the ratio of abdominal and inguinal testes to uncomplicated cryptorchidism. The authors say that bilateral tumors occur predominantly in the reproductive years of life, but they remark that the first tumor in such cases usually occurs later in life than does the unilateral tumor. The greatest number of both unilateral and bilateral tumors, and especially those occurring during the reproductive years, are unicellular types.

The relative percentages of the various types of tumors are the same for bilateral as for unilateral cancer, save for the fact that chorionepitheliomas are not found bilaterally. Hamilton and Gilbert advance additional evidence to the effect that prenatal factors are significant in

48. Adams, J. E.: A Study of Malignant Testicular Tumors Including Case Reports of Chorionepithelioma Accompanied by Hypertension and Teratoma Testis with Single Tridermal Metastases, J. Urol. **47**:491-507 (April) 1942.

49. Hamilton, J. B., and Gilbert, J. B.: Studies in Malignant Tumors of the Testis: IV. Bilateral Testicular Cancer; Incidence, Nature and Bearing upon Management of the Patient with a Single Testicular Cancer, Cancer Research **2**:125-129 (Feb.) 1942.

a patient's predisposition to testicular cancer. It is possible, they believe, that estrogens may play a role in the instigation of cryptorchidism and that gonadotropins may operate in the stimulation to carcinogenesis during the patient's so-called reproductive years of life. They say that management of the patient who has cancer of one testis must be concerned with the possibility that primary involvement of the other testis may occur. Despite the usually rapidly fatal course of the patient who has testicular cancer, a tumor has appeared in the other testis of 15 per cent of those who had inguinal testes and in the other testis of 30 per cent of those who had abdominal testes. The second testis of a man suffering from bilateral cryptorchidism and cancer of one testis must be viewed as a site of potential carcinogenesis.

Hamm [50] reports a case in which a Wilms tumor afflicted a 64 year old man. The patient complained chiefly of hematuria. Cystoscopic examination showed that bloody urine was coming from the right, and that clear urine emerged from the left, ureteral orifice. The pyelogram of the left kidney was normal; that of the right kidney showed some obstruction characteristic of renal tumor. The right kidney was removed, and histologic examination revealed a mixed tumor containing carcinomatous and sarcomatous structures.

Graves and Lawrence [51] discuss bilateral embryonal carcinoma of the testicle and report a case. Their patient was a man 33 years old who had noticed that a slight enlargement of the right testicle had been present for two years. Orchidectomy was refused. At about this time the left testicle started to enlarge. On examination, a mass in the lower part of the abdomen was found. The left testicle was removed first; later the right one was excised. The diagnosis was embryonal carcinoma of the testicle. Roentgen therapy was also administered. Ten months later the patient reported that he had lost 5 pounds (2.3 Kg.). He complained of nothing else and was working.

Graves and Lawrence state that they favor external irradiation rather than surgical intervention as the primary form of therapy in the treatment of such patients, whether they do or do not have metastasis. Orchidectomy is performed in such a program when the full effect of irradiation has been obtained in the testicle and when the local reaction in the scrotum has subsided. In all their cases, regardless of whether the primary tumor is removed or irradiated and whether demonstrable metastasis is present or not, a full series of treatment with roentgen rays is always administered and is always understood to include treatment

50. Hamm, F. C.: Wilms' Tumor in a Sixty-Four Year Old Male: Report of a Case, J. Urol. **47**:403-409 (April) 1942.

51. Graves, R. C., and Lawrence, K. B.: Bilateral Embryonal Carcinoma of the Testicle with a Note on the Technique of Orchidectomy for Malignant Disease, Tr. Am. A. Genito-Urin. Surgeons **34**:227-236, 1941.

by maximal dosage through both the anterior and the posterior portals of all the lymph gland–bearing regions *on each side,* from the pelvis to the diaphragm. The thorax is not treated unless there is roentgenologic evidence of involvement in this region or unless palpable supraclavicular lymph nodes are present. Under such circumstances the thorax and the neck are included in the roentgen treatment. Graves and Lawrence say that surgical dissection of retroperitoneal glands should be reserved for those unusual and desperate instances in which the malignant tumor is of a type resistant to radiation, as evidenced by its response to treatment or by the pathologic report, if the testicle has been removed.

Graves and Lawrence say that they have been making some exceptions to the rule that irradiation should be carried out first. In early stages of tumors, when only slight changes can be felt in the involved testicle and when the presence of a neoplasm can be suspected only, they think that prompt and early diagnosis cannot be obtained except by prompt and early orchidectomy. Graves and Lawrence emphasize the importance of careful technic in the performance of orchidectomy in the presence of malignant disease of the testicle, positive or suspected. By means of such technic the likelihood of widespread dissemination of that disease through manipulation of the tumor can be minimized. They say that no more vicious tumor occurs in the male genitourinary system, and declare that there is none which is more readily disseminated, than carcinoma of the testicle. They prefer a somewhat more radical procedure than that commonly employed. In all the examinations and preparations for operation, the scrotal contents are treated with the utmost gentleness. The inguinal canal is opened first, without inclusion of the scrotum in the incision, and it is opened high enough to permit adequate exposure of the spermatic cord at the level of the internal inguinal ring. At this level the cord is doubly ligated with as little trauma as possible and without the application of clamps. It is then divided between the ligatures with the cautery or cutting current. At this stage the incision can be extended downward sufficiently to permit removal of the distal portion of the cord from its bed and to allow gentle enucleation of the testicle, with its intact tunic, from the cavity of the scrotum. Great care should be taken not to incise the tunica vaginalis or to cut into the tumor at any point. This procedure, according to Graves and Lawrence, avoids all manipulation of the malignant process until its lymphatic and vascular connections with the body have been severed.

Graves and Lawrence [52] report a case in which bilateral embryonal carcinoma of the testicle had afflicted a 33 year old patient. The two

52. Graves, R. C., and Lawrence, K. B.: Bilateral Embryonal Carcinoma of the Testicle with a Note on the Technique of Orchidectomy for Malignant Disease, J. Urol. **47**:482-490 (April) 1942.

tumors were of large size and exhibited evidence of metastasis to retroperitoneal lymph nodes. Preliminary bilateral orchidectomy was done. Clinical disappearance of the metastatic disease followed the administration of high voltage roentgen ray therapy directed to the abdomen and pelvis. The patient was alive and without definite evidence of disease about ten months after treatment.

Torsion of the Testicle.—Ownby and Atkinson [53] state that torsion of the testicle should be more nearly accurately called "torsion of the spermatic cord." Torsion is caused by a sudden axial rotation of the testicle or testes. This causes constriction of the blood vessels of the spermatic cord and results in an acute circulatory disturbance of the testes and adnexa. In 75 per cent of cases the patients are less than 21 years old. Wallenstein is said to have found that in 144 cases the condition occurred on the right side and that in 142 cases it occurred on the left side. He also is said to have found 24 cases in which the condition occurred bilaterally. Pain—sudden, sharp and severe—is common. It usually follows some sort of muscular effort. As swelling increases pain becomes more severe. When the condition is recurrent pain may be intermittent. Unilateral edema of the scrotal skin occurs early and is sharply limited to the side on which the torsion is exerted and extends up to the site of the twist, with fixation of the skin to the underlying scrotal contents. There is retraction of the scrotal contents upward, brought about by shortening of the cord. The epididymis, if it is palpable, occupies an abnormal position in relation to the testis. In later stages, distinction between epididymis and testis is impossible. Elevation of the scrotum increases the pain; but when epididymitis is present such a procedure usually relieves the pain. The diagnosis frequently is erroneous. The most important factor is that the physician consider the possibility that torsion may be present in every case of pain and swelling in the scrotum. Possibility of the presence of torsion must be considered in every case of inguinal swelling with which pain is associated, particularly if the testicle is not palpable in the scrotum. This applies to every male from birth to old age.

Ownby and Atkinson state that to be effective treatment must be instituted early. Detorsion rarely has been successful. Although the direction of torsion usually is clockwise on the right and counterclockwise on the left, there is no certainty that these conditions will be present in any given case. As an emergency procedure, detorsion may be attempted, but such an attempt should be gentle. Even if the detorsion is sucessfully effected, surgical exploration of the testicle and orchidopexy or orchectomy are indicated. When either of the procedures is

53. Ownby, J., Jr., and Atkinson, R. C.: Torsion of the Testicle, California & West. Med. **56**:251-253 (April) 1942.

performed the contralateral testicle should be anchored, since the same anatomic conditions predisposing to torsion usually are present in that testicle.

Blood Supply.—Golder and Wildbolz [54] discuss the blood supply and anastomosing vessels of the testis and epididymis. They report an investigation carried out on 54 testicles that had been obtained by surgical removal or at necropsy. After initial experiments to determine the choice of the dye and the roentgenographic methods to be used, optimal results were gained by injection of a mixture of a colloidal suspension of thorium dioxide (thorotrast) and methylthionine chloride U. S. P. (methylene blue) into the arterial system; in most cases the mixture was injected into the internal spermatic artery. In cases in which conditions were favorable the whole system (internal and external spermatic artery, deferential artery and pampiniform plexus) became clearly visible in the stereoscopic roentgenogram. Golder and Wildbolz describe a number of variations of the blood supply. First, the internal spermatic artery reaches (or its main branches reach) the testicle in the middle third of its posterior aspect. The further course inside the testicle takes place in one of the following ways: (1) without further division, through the middle of the parenchyma of the testicle from the back to the front aspect, (2) by passing down the posterior aspect around the inferior globe, (3) by entrance through the tunica albuginea in two main branches, one following type 1 and the other following type 2, (4) by splitting up into several branches, penetrating on different heights on the back aspect, and (5) by division into several branches immediately after entrance through the tunica albuginea.

In a second variation of the blood supply, anastomoses of the internal spermatic artery with the deferential artery occur according to the following main types: (1) When anastomosis is external, the deferential artery connects with a branch of the internal spermatic artery over the posterior aspect of the epididymis, and (2) when anastomosis is internal, the anastomosis lies inside the tunica albuginea. Two variants are possible: (1) connection in the superior and (2) connection in the inferior testicular pole. In Bevan's operation for undescended testicle, during mobilization of the dystopic testicle it is necessary to divide the vascular plexus of the internal spermatic artery as far as possible from the testicle in order to insure eventual anastomosis with the deferential artery. In epididymectomy, the anastomosis in the region of the lower portion of the epididymis which passes to the inside

54. Golder, O.: Die Arterien des menschlichen Hodens und Nebenhodens, ihre Anastomosen und deren Bedeutung in der Chirurgie, Ztschr. f. urol. Chir. u. Gynäk. **45**:406-422, 1940. Wildbolz, H.: Die Arterien des menschlichen Hodens und Nebenhodens. (Nachwort zu der Arbeit von O. Golder), ibid. **46**:5-6, 1941.

of the testicle must be ligated as far as possible from the testicle. Ligations eventually necessary in the tunica albuginea may lead to ligation of the internal spermatic artery and therefore to partial or total necrosis of the testicle. Golder and Wildbolz consider the results of these experiments on the blood supply to be of great value in the performance of epididymectomy. They say that in recently reviewed cases orchidectomy has been much more common than epididymectomy, even in cases of epididymitis.

There have been two objections to the performance of epididymectomy. First, in inflammatory diseases, especially in cases of tuberculosis, it was thought that the testicle also became infected early in the course of the disease and that epididymectomy was not sufficient. This has been disproved by pathologic and anatomic investigation. Second, it has been said that atrophy of the testicle occasionally results after epididymectomy. According to Golder and Wildbolz, careful surgical technic and preservation of the blood supply will prevent this.

The greatest danger to the testicle from injury to the vessels does not arise in separation of the superior globe, but in isolation of the body of the epididymis. Incision must be made very close to the epididymis in order to preserve the internal spermatic artery, which enters the posterior part of the testicle in the middle third portion. Hemostasis must be carried out carefully, because the spermatic artery and its branches sometimes adhere very closely to the testicular capsule. Ligation of the vessels must be superficial and carried out with small instruments. The same care must be taken in removal of the inferior portion of the epididymis, since in some cases there is a variation in the course of the spermatic artery, and it may enter at the lower portion of the testicle.

Infertility.—Charny and Meranze,[55] in discussing biopsy of testicular tissue in cases of male infertility, say that it is an innocuous procedure and that it should be established as a routine procedure in these cases. Failure of tubular development is indicated histologically by the presence of small tubules which are filled with undifferentiated cell forms. Peritubular fibrosis is not present. Degenerative lesions, if acute, can be recognized in biopsy of testicular tissue by the presence of necrosis and desquamation of the tubular epithelium. If the lesions are long standing, peritubular fibrosis is a distinct feature and signalizes either the end stage of an inflammatory process or the replacement fibrosis which results from shrinkage of the tubules.

The presence of peritubular fibrosis suggests severe damage to the youngest epithelial cells of the tubules, and this damage probably has

55. Charny, C. W., and Meranze, D. R.: Testicular Biopsy: Further Studies in Male Infertility, Surg., Gynec. & Obst. **74**:836-842 (April) 1942.

affected their regenerative potentialities. The administration of an estrogen or an androgen, such as diethylstilbestrol or testosterone propionate, induces tubular degeneration, both in the hypersexual male and in the patients with hypogonadism. Charny and Meranze say that the majority of male patients of relative infertility have no endocrine disturbances. Deficiencies in their semen are the results of degenerative lesions of the seminiferous tubules caused by either regional or constitutional inflammatory or toxic processes. Endocrine therapy, they declared, is not indicated in such instances.

Tumor of Epididymis.—Friedman and Grayzel [56] report a case in which tumor of the epididymis afflicted a 57 year old man. On examination the left testicle was found to be about four times normal size. The epididymis was stony hard, and the cord was thickened. Orchidectomy was done, and a diagnosis was made of "fibrous myoma of the epididymis." Friedman and Grayzel summarize data of thirteen collected cases and find that the average age of the patients was 44 years. The usual history was that of gradual increase in the size of a painless scrotal tumor. In most cases the tumor was hard, round, nodular and not tender. The treatment is epididymectomy. If the testicle is found to be involved, a frozen section should be prepared and studied histologically before complete removal of the epididymis and castration are attempted.

O'Brien [57] reports a case of primary sarcoma of the epididymis. He states that there are, inclusive of his report, only 92 cases recorded in the literature. The role trauma plays in the causation of tumors of the epididymis and testicle, a subject of controversy, is significant, he says. The train of events in O'Brien's case, as well as in the cases of others, justifies this opinion. In all cases of scrotal or testicular injury the patient should be kept under prolonged observation. In O'Brien's case, a fibrosarcoma developed within six months after the patient had sustained a violent blow to the scrotal region. Metastasis to bone may occur to an unpredictable degree. The usual sites of localization are the lumbar vertebrae and, to a lesser extent, one distant bone or more. In no case referred to by O'Brien was there such rapid and widespread dissemination as occurred in his own case.

Cyst of Epididymis.—Baird [58] reports a case in which a cyst of the epididymis became twisted on its pedicle. The patient was a boy of

56. Friedman, H. H., and Grayzel, D. M.: Myomatous Tumors of the Epididymis, J. Urol. **47**:475-481 (April) 1942.

57. O'Brien, M. G.: Primary Sarcoma of the Epididymis: Case Report, J. Urol. **47**:311-319 (March) 1942.

58. Baird, S. S.: Cyst of the Epididymis Twisted on Its Pedicle: Case Report with Review of the Literature, J. Urol. **47**:372-378 (March) 1942.

15 years who complained of pain in the left groin and also of swelling and pain in the left side of the scrotum. At operation a small intravaginal purplish cyst was found below the testis; it was joined by a short pedicle to the tail of the epididymis. The pathologic diagnosis was "benign cyst of the epididymis." Operation is the treatment of choice in similar cases of torsion of the appendages of the testis and epididymis. Baird quotes Randall's statement: "The operation is so simple, and so devoid of any serious complications, that it should always be advised. . . . The question of conservative—nonoperative—treatment is ill-advised: (1), because no local treatment relieves the distress; (2), because detorsion and recurrent attacks are possible; (3), because the nonoperative recovery can take longer than the operative removal and convalescence."

Calcification of Vas Deferens.—Lowsley and Riaboff [59] review 32 cases of calcification of the vas deferens, ampulla of the vas and seminal vesicle (31 taken from the literature and 1 case of his own). Their study reveals that this condition may occur at any age of the patient, from youth to senility. The youngest patient who had the condition was 14 years of age; the oldest was 81 years old. In 12 cases, or in more than a third, calcification had occurred after the patients had reached the age of 60 years; in 5 cases the patients were between the ages of 50 and 60 years; 3 patients were in the fourth decade; 1 was in the third decade, and 3 were in the second decade. Of the 32 cases studied, the condition was found at necropsy in 21. In 1 case it was found at operation, and in only 10 cases, including Lowsley and Riaboff's case, had the condition been diagnosed clinically in the living patient.

PENIS

Plastic Induration.—Volavsek [60] reports 198 cases of plastic induration of the penis from the Dermatologic Clinic of Vienna. The reaction of connective tissue to local hypertrophy is one of the most common causes of this condition, and in addition there are various irritative factors which are important, such as mechanical trauma and disturbance of circulation to the tissues. Of all the patients, 4.6 per cent had an associated digital Dupuytren's contracture. On the other hand, 34 per cent of the patients who had Dupuytren's contracture also had plastic induration of the penis. Of the patients treated with radium, 32.8 per cent progressed to complete recovery; 47 per cent were partly

59. Lowsley, O. S., and Riaboff, P. J.: Calcification of the Vasa Deferentia, J. Urol. **47**:293-298 (March) 1942.

60. Volavsek, W.: Zur Kenntnis der Induratio penis plastica (mit bes Berücksichtigung ihrer Beziehung zur Dupuytren'chen Kontraktur), Ztschr. f. Urol. **35**:173-175, 1941.

healed, and the condition of the rest was not influenced. In those cases in which definite calcification or ossification had occurred, it was necessary to remove calcified tissue by surgical operation. Volavsek says that in his opinion radium provides the best results of any type of treatment.

Phimosis.—Hoffmann [61] reports a case in which complete phimosis developed after circumcision of a 4 week old baby. Urinary stasis occurred, necessitating a second operation.

Periurethral Extravasation.—Steller [62] discusses some anatomic aspects of the periurethral fasciae. He distinguishes three different layers. First, he disagrees with the descriptions of some other observers, who have reported complete involvement of the penis and scrotum by a continuous fascial layer. The first of the three layers of fascia reported by Steller is Colles' fascia, which is composed of the superficial abdominal fascia, the cremasteric fascia, the superficial perineal fascia and the penis. He states that the scrotum has no fascial layer corresponding to this complex group and remarks that this grouping of fasciae is important in the localization and spread of urinary extravasation. The second layer of fascia consists of the aponeuroses of the internal and external oblique muscles, the suspensory ligament of the penis, the external periosteal layer of the pubic bone and the external sheet of the urogenital diaphragm. The third fascial layer is composed of the fascia of the transverse abdominal muscles, the internal periosteal layer of the pubic bone and the internal sheet of the urogenital diaphragm.

In 90 per cent of cases of periurethral urinary extravasation, stricture of the urethra was found. Extravasation occurred usually just distal to the point of the lesion. Seventy-five per cent of the patients earlier had had gonorrhea. Further development of the pathologic processes, says Steller, depends on the extent of the urinary infection. Ammoniacal decomposition of the urine, which commonly is present, is said to favor an anaerobic type of infection (usually caused by Borrelia refringens). The spread of the extravasation is greatly increased by the movement and position of the different layers of periurethral fascia. Steller also describes three different types of spread of extravasation. In the first the infection starts from the bulbous portion of the urethra and spreads by means of the superficial fascia and the skin. This results in infiltration of the perineum, the scrotum and the inguinal and pubic regions. The prognosis is good. In the second infection occurs in the

61. Hoffmann, W.: Schwielenbildung und Verengerung des Harnröhreneingangs nach Phimosenoperation, Schweiz. med. Wchnschr. **70**:142-143 (Feb. 17) 1940.

62. Steller, L.: Die periurethrale Urinifiltration und die periurethralen Faszien (eine anatomische und klinische Studie), Ztschr. f. Urol. **35**:192-204, 1941.

membranous portion of the urethra, and the infection spreads between the two sheets of the urogenital diaphragm. Later, rupture of the diaphragm occurs, either outwardly or inwardly; at times accompanied by infiltrations of the pelvic organs. The prognosis is bad. In the third infection spreads from the prostatic urethra, with infiltration of the organs of the pelvis, not uncommonly causing death of the patient. The treatment of all patients is incision of the extravasated region and drainage of the bladder; but neither is sufficient without the other.

THERAPY WITH SULFONAMIDE COMPOUNDS

Hendricks,[63] in discussing changes in the blood resulting from the administration of sulfonamide compounds, states that in 40 per cent of 433 patients who received one or more of these compounds mild to severe anemia developed. The percentage of total instances of anemia was about the same for sulfanilamide, sulfapyridine and sulfathiazole. Infants and children who received sulfanilamide or sulfapyridine were more susceptible to severe anemia than were adults. Although anemia developed among 50 per cent of infants and children who were treated with sulfathiazole, no severe or moderately severe changes occurred in any. In all age groups, severe or even moderately severe anemia occurred less frequently when sulfathiazole was administered than it did when sulfanilamide or sulfapyridine was employed.

The number and severity of the various types of anemia were not dependent on the total doses received by the patients, the duration of treatment or the concentration of the drug in the blood. Therefore Hendricks concludes that the administration of small doses for a longer period than is usual is no insurance against the development of anemia. Leukopenia developed among 2.3 per cent of patients, and in 4 cases leukopenia proceeded to agranulocytosis, with 2 deaths. Hendricks said that blood counts must be made routinely every two to three days during the entire course of treatment with any of the sulfonamide compounds. Since reactions may occur after cessation of therapy, patients should be kept under surveillance after treatment has been discontinued.

Keitzer and Campbell [64] report 11 cases in which renal complications appeared secondary to the administration of sulfadiazine. Complications usually appeared by the seventh day of administration of this drug. The average daily dose was 5.5 Gm. The average concentration of the drug in the blood was 11 mg. per hundred cubic centimeters. This suggests that a safe dose is 4 Gm. a day and that a safe concentration of the drug

63. Hendricks, C. B.: Sulfonamide Compounds: Blood Changes Therefrom, California & West. Med. **56**:253-257 (April) 1942.

64. Keitzer, W. A., and Campbell, J. A.: Renal Complications of Sulfadiazine, J.A.M.A. **119**:701-703 (June 27) 1942.

in the blood is one of not more than 8 mg. per hundred cubic centimeters. They believe that sulfadiazine, since it is better tolerated by the stomach, is a more dangerous drug in respect to its power to produce renal complications than are others, because physicians are more likely to be less vigilant when a drug appears to be well tolerated. Keitzer and Campbell advise the following method of treatment in any type of renal complications caused by sulfonamides:

1. Administration of the drug should be halted immediately at the first sign of hematuria, renal colic or oliguria.

2. Fluids should be forced.

3. If oliguria is present, with an output of urine of 500 cc. or more, a delay of from twelve to twenty-four hours before cystoscopic examination is undertaken, in the hope that diuresis will relieve the situation, may be tried.

4. Cystoscopy and catheterization of the ureters should be carried out immediately when oliguria persists or anuria is present.

5. The ureteral catheters should be left in place as indwelling catheters for from twenty-four to forty-eight hours, until the return flow of urine is clear.

6. Kidneys should be irrigated with a warm 2.5 per cent solution of sodium bicarbonate or with a warm isotonic solution of sodium chloride. Keitzer and Campbell have at times alkalized the patient intravenously as well as orally.

7. Retrograde pyelograms should be made prior to withdrawal of the catheters.

Huber [65] reports a case in which anuria occurred secondarily to the administration of sulfapyridine. Both ureters of the patient were completely filled with crystals. Ureteral catheterization was carried out, but death resulted from cardiac failure.

Cook [66] reports his experience with sodium sulfathiazole in the treatment of approximately 200 patients who had infection of the urinary tract. He used a dose of from 20 to 60 Gm. daily for a period of six to ten days and found that (1) gram-positive organisms were affected equally well except for members of the genus Pseudomonas, which were most obstinate to treatment, and that (2) gram-positive cocci, except for Streptococcus faecalis, all responded satisfactorily. Cook also notes that the drug exerted its effects very promptly, on account of its rapid absorption, and that its toxic effects were almost nil.

65. Huber, W.: Ergänzender Beitrag zur Frage der Dagenan- Komplikationen, Schweiz. med. Wchnschr. **70**:884-885 (Sept. 14) 1940.

66. Cook, E. N.: Sodium Sulfathiazole in the Treatment of Infections of the Urinary Tract, Proc. Staff Meet., Mayo Clin. **16**:717-718 (Nov. 5) 1941.

Helmholz [67] is of the opinion that the ideal urinary antiseptic agent has not been found. Theoretically it should be one that would act in a urine of any reaction and one that would be excreted by the damaged kidney in a bactericidal concentration. Although it is not ideal, sulfathiazole is bactericidal for six of the most common bacteria found in infections of the urinary tract. He found that a concentration of the drug in the blood of 200 mg. per hundred cubic centimeters was sufficient for the cure of practically all infections excepting those caused by members of the genus Pseudomonas, which probably will require the concentration in the blood to be 300 mg. per hundred cubic centimeters. He found that the effectiveness of the drug for the various bacteria (on an ascending scale) is as follows: Pseudomonas aeruginosa, Str. faecalis, Escherichia coli, Aerobacter aerogenes, Proteus ammoniae and Staphylococcus aureus. He also noted that there was some variation in the effect of the drug at various values for p_H, and that this characteristic was particularly marked in the case of Streptococcus faecalis.

By experiments in vitro on the Str. faecalis, Helmholz [68] undertook to determine the efficacy of sulfathiazole in the treatment of urinary infections. For this purpose he carried on a series of experiments with urine at a p_H of 6.5, 6.0, 5.5 and 5.0, and with concentrations of 10, 20, 30, 50 and 100 mg. of the drug per hundred cubic centimeters of urine. For controls, he used drug-free specimens of urine at hydrogen ion concentrations of 5.1, 5.0, 4.9 and 4.8. He found that there was a sharp dividing line in the growth of streptococci in the controls in urine at a p_H between 5.0 and 4.9. At a p_H of 5.1 and at a p_H of 5.0 there was marked growth in all experiments, whereas at a p_H of 4.8 there was absolutely no growth. Thus, by means of acidity alone Helmholz was able to obtain a bactericidal effect on Str. faecalis. He also found that at a p_H of 5.0 there was growth of practically all strains of Str. faecalis, but that the addition of only 10 mg. of sulfathiazole produced a 100 per cent bactericidal effect. At a p_H of 5.5 there was some inhibition of growth at all concentrations of the drug from 10 to 100 mg. per hundred cubic centimeters. At a p_H of 6.0 bactericidal activity was present only with concentrations of 50 and 100 mg. of the drug. At a p_H of 6.5 no bactericidal or bacteriostatic activity occurred with concentrations of 10, 20 and 30 mg. of the drug, and only slight bacteriostasis was noted with concentrations of 50 and 100 mg. Helmholz also studied the relative effects of 100 mg. of sulfathiazole and sulfanilamide on three

67. Helmholz, H. F.: The Use of Sulfathiazole as a Urinary Antiseptic, J. Urol. **45**:135-145 (Jan.) 1941.

68. Helmholz, H. F., and Alford, H.: The Bactericidal Action of Sulfathiazole on the Streptococcus Faecalis, Proc. Staff Meet., Mayo Clin. **16**:737-744 (Nov. 19) 1941.

strains of Str. faecalis at a p_H of 5.5, of 6.0 and of 6.5, and noted that when sulfanilamide was employed the streptococci grew out abundantly, whereas when sulfathiazole was used the number of colonies was reduced in all three strains at a p_H of 5.5 and in two strains at a p_H of 6.0 and of 6.5. Helmholz deduces, on the basis of these experiments, that growth of Str. faecalis in urine is inhibited at a p_H of 4.9 and that sulfathiazole has a greater bactericidal action when the p_H is low. Furthermore, he is of the opinion that sulfathiazole is definitely superior to sulfanilamide in its bactericidal action on Str. faecalis.

Fisher and Haag [69] state that sulfacetimide [70] administered orally to mice and dogs appears to be about a fourth as acutely toxic as sulfanilamide similarly administered. Doses of 5 Gm. of sulfacetimide per kilogram of body weight administered orally to dogs were better tolerated, that is, produced fewer signs of acute poisoning than were observed among the same dogs after the administration of 2 Gm. of sulfanilamide per kilogram of body weight.

The rate of growth of young rats maintained on a diet containing 1.5 per cent of sulfacetimide showed no significant retardation as compared to that of control animals maintained on a similar diet not containing the drug. Two dogs which received 0.4 Gm. of sulfacetimide per kilogram of body weight daily for eleven weeks exhibited no loss of weight, no significant changes in the number of leukocytes or erythrocytes or in the value for hemoglobin, and no demonstrable pathologic changes in the liver, spleen, kidneys, adrenal bodies, stomach or intestines. The daily administration of 1 Gm. of sulfacetimide per kilogram of body weight was not tolerated for eleven weeks by 2 of 3 dogs for which such a regimen was initiated. Although necropsy of the 2 dogs did not reveal causative anatomic changes in the kidneys, results of studies of blood chemistry suggested that failure of the excretory function of the kidneys was probably responsible in large degree for the death of the 2 animals. The 1 animal living at the end of the eleven week period was not found to have any abnormalities of the tissues at necropsy. Among mice and dogs, a given concentration of sulfacetimide in the blood is less likely to be accompanied by signs of intoxication, regardless of the dose required to produce this concentration, than is a similar concentration of sulfanilamide in the blood. Fisher and Haag believe that there is evidence which suggests that sulfacetimide is more readily absorbed and eliminated by the mouse and by the dog than is sulfanilamide.

69. Fisher, R. S., and Haag, H. B.: Studies of the Comparative Toxicity, Absorption and Elimination of Sulfacetimide and Sulfanilamide, J. Urol. **47**:183-195 (Feb.) 1942.

70. Acetylsulfanilamide.

Schultz, Shidler and Niebauer [71] report a case in which acute urinary suppression followed the use of sulfadiazine. They report the signs and symptoms of beginning renal failure during the period of use of sulfadiazine as being microscopic and gross hematuria, crystalluria, pain in the abdominal region and the flanks, a decreased output of urine and nausea and vomiting. Their treatment consists of the forcing of fluids and of alkalization of the urine. If the output of urine decreases considerably, cystoscopic examination, ureteral catheterization and lavage are immediately indicated, with the institution of continuous urinary drainage by means of indwelling ureteral and vesical catheters. Subsequently, the renal pelvis should be irrigated with a 2 per cent solution of sodium bicarbonate every three to four hours. Catheters are to be removed when the output of urine has returned to normal. The deposition of sulfadiazine crystals in the renal pelves and ureters produces mechanical anuria. Sodium bicarbonate in amounts sufficient to alkalize the urine should be administered simultaneously with sulfadiazine.

Newman and Shleser [72] report a case of renal calculus due to sulfapyridine and sulfanilamide. The patient, a man 38 years old, had received these drugs for pneumonia. Two years later a roentgenogram revealed the shadow of a large renal calculus in the right renal area. The urine contained blood cells, and culture disclosed bacilli of the genus Proteus. At operation two stones were removed from the pelvis of the kidney; they were of the earthy, phosphatic type. Chemical analysis revealed large quantities of sulfonamide compounds mixed with the protein.

Winsor and Burch [73] discuss the renal complications which can follow sulfathiazole therapy and report 6 cases which illustrate some of the renal problems encountered in such therapy. Injury has been noted as resulting more from sulfapyridine therapy than from sulfathiazole therapy. This situation most probably is due to the fact that the latter drug has been used for only a relatively short time. It is too early to evaluate the status of sulfadiazine and sulfaguanidine, so far as renal damage is concerned. Sulfanilamide appears to be much less likely to injure the kidneys seriously. Winsor and Burch do not believe that the diagnosis of renal damage is difficult. The appearance of

71. Schultz, J. W.; Shidler, F. P., and Niebauer, J. J.: Acute Urinary Suppression Following Sulfadiazine Therapy, J.A.M.A. **119**:411-413 (May 30) 1942.

72. Newman, H. R., and Shleser, I. H.: Sulfonamide Renal Calculus Surgically Removed Two Years After the Administration of Sulfapyridine, J. Urol. **47**:258-261 (March) 1942.

73. Winsor, T., and Burch, G. E.: Renal Complications Following Sulfathiazole Therapy, J.A.M.A. **118**:1346-1353 (April 18) 1942.

hematuria, oliguria, backache, tenderness over one or both renal areas, decreased renal function, azotemia and progressive nephromegaly in a patient who has received sulfathiazole should make the physician suspect that renal damage has arisen from the drug. Cystoscopic study usually will establish the diagnosis. Sulfathiazole crystals in the urine may aid in establishment of the diagnosis, but their presence alone does not mean that renal damage has occurred. Roentgenologic study usually will not reveal uroliths unless there is calcification, which is rare. Winsor and Burch warn that because of the tendency of sulfathiazole to injure the kidneys it is necessary to employ the drug cautiously. First, the physician should determine whether or not the patient has had medication with a sulfonamide compound before. If the history is not reliable, it is advisable to determine the concentration of the drug in the blood and to prescribe accordingly. This will tend to prevent overdosage and to reduce the likelihood of injury to the kidneys. Second, the state of the patient's renal function and the nature of the urine being excreted should be evaluated before the physician begins to administer the drug. Third, the status of hydration of the patient should be evaluated. A severely dehydrated patient will take in much fluid and excrete but little and therefore will be more likely to experience renal damage. Fourth, an alkaline urine tends to reduce the formation of crystals, and if the use of alkalis and the maintenance of an alkaline urine are not contraindicated in a particular case, it would be well to administer alkalis and to maintain an alkaline urine. Fifth, there is some evidence to indicate the development of hypersensitivity to sulfonamide compounds. It is well, therefore, to be extremely cautious and particularly vigilant in the treatment of patients who already suffer from a form of allergy. Administration of the drug should be stopped immediately, once the slightest evidence of renal damage is discovered. Winsor and Burch recommend that fluids be administered in large quantities. Ureteral catheterization should be carried out promptly, and the catheter should be allowed to remain in place until a normal volume of urine flow has been reestablished. The renal pelves should be irrigated at two hour intervals with warm (107 F., or 41.6 C.) distilled water. Diuretic agents should have the form of large quantities of fluid and, if necessary, hypertonic solutions of dextrose. If possible the use of magnesium sulfate should be avoided, because it predisposes to the formation of sulfhemoglobin; but it may be used intravenously if cyanosis is not present and if the oliguria persists after other measures to induce diuresis have failed. Mercury and acid diuretic agents should not be used. The patient should be maintained on an alkaline ash diet, and the urine should be kept alkaline with the use of sodium bicarbonate. The intake of protein should be restricted for four or five days, or during the period of severe oliguria,

hematuria and azotemia. Fluids should be administered in large quantities for many days after the kidneys have returned to normal.

Lindner and Atcheson [74] state that the use of sulfathiazole may lead to very serious renal sequelae, and that the physician always should be alert to detect these sequelae when the drug is used. The patient's urine should be checked daily as to volume of output, hematuria, crystals, albuminuria and casts; and the intake of fluids should be known. Sulfathiazole is rapidly excreted in the urine and tends to precipitate, especially if the urine is acid. In use of the drug, care must taken to see that sufficient fluids accompany it. Lindner and Atcheson point out that the concentration of sulfathiazole in the blood does not indicate the degree to which the crystals are precipitated. Sulfathiazole concretions are not radiopaque. The crystals tend to produce multiple hemorrhages throughout the renal parenchyma and mucosal linings. Such hemorrhages may even be of advanced degree, with massive destruction of parenchyma. The crystals may produce anuria by mechanical block in the ureters, but it is more likely that the serious blockages are those which occur in the tubules. Lavage and removal of blockage at the lower level will lead to an increased output of urine, up to a certain point. Lindner and Atcheson report that the best therapy at present is renal lavage carried out with warm water by means of ureteral catheters supplemented by the forcing of fluids, alkalization of the urine and the use of heat.

Hughes, Sayen and LaTowsky [75] state that a collection of crystals of sulfadiazine forming actual urinary calculi may occur in the urinary tract. Obstruction to the flow of urine may or may not occur because of these collections. If obstruction does occur, it can be treated successfully by bilateral ureteral catheterization and the forcing of fluids. In the reported case, the urine was persistently acid. It has been shown that sulfadiazine is less soluble in acid urine than in alkaline urine. Maintenance of an alkaline urine might have aided in prevention of the complication of crystal agglomeration.

URINARY INFECTION

Heldfond [76] presents an analysis of 145 cases of pyelonephritis of pregnancy and compared the results obtained with various chemotherapeutic agents. The distinct superiority of sulfonamide compounds was demonstrated, and of those used sulfapyridine was found to be the least effective and sulfathiazole by far the most effective.

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74. Lindner, H. J., and Atcheson, D. W.: Sulfathiazole Crystallization in the Kidney, J. Urol. **47**:262-266 (March) 1942.

75. Hughes, P. B.; Sayen, J. J., and LaTowsky, L. W.: Sulfadiazine Calculi in the Urinary Tract: Report of a Case, J. Urol. **47**:274-276 (March) 1942.

76. Heldfond, A.: The Treatment of Urinary Tract Infections of Pregnancy, West. J. Surg. **50**:82-84 (Feb.) 1942.

DILATATION OF URINARY TRACT

Treite [77] states that all the cavities of the urinary tract may undergo congenital enlargement, such as hydronephrosis, megaloureter and megacystitis. There is no sharp demarcation, he said, between extreme dilatation and normal size. Occasionally, there are associated anomalies of other organs, such as dilatation of the intestinal tract (megaesophagus and megacolon, also called "Hirschsprung's disease"). Enlargements of the female genital tract also have been noted, such as hydrometra and hydrocolpos. Treite reported 13 cases of fetal enlargement of the bladder. The patients were observed in Stoeckel's clinic in Berlin. From the genetic standpoint, the condition is divided into three types. First is megacystitis, an anomaly of genesis or so-called excess formation, often associated with other excess formations of the urinary tract, such as hydronephrosis and hydroureter. The wall of the bladder shows an abnormal thickness, including both the muscular and the mucous layer, in spite of the size of the organ. Second is enlargement of the bladder by distention (constriction of the neck of the bladder and obstruction of the urethra). The walls are thin and smooth, without folds. Patients have been observed who exhibited formation of valves of the urethral orifice and also complete atresia of the urethral outlet. Secretion of urine normally does not exist during fetal life; hence, true distention of the bladder can occur only postnatally or by marked disturbance of placental metabolism and circulation. Third, there are many cases in which the walls of the bladder are definitely distended but in which no urethral obstruction is found. In these cases other megaformations of the urinary tract are rarely found, but not uncommonly there is an associated megacolon. Distention of the bladder without anatomic reason usually is caused by functional factors of nervous origin, such as (1) hyperfunction of the sympathetic nerves, (2) persistence of the aorticolumbar paraganglion (Zuckerkandl's organ) and (3) intervention of the hypogastric nerve. Treite also considers that among pregnant women hormonal factors may cause distention of most of the organs of the female pelvis.

UROGRAPHY

Goldburgh and Baer [78] report a case in which death followed the intravenous administration of 3,5-diiodo-4-pyridone-N-acetic acid diethanolamine (diodrast). The patient was elderly and had complained of numerous conditions. She had had diabetes for fifteen years and had

77. Treite, P.: Zur Pathologie der angeborenen Harnblasenerweiterungen, Ztschr. f. Urol. **35**:117-140, 1941.

78. Goldburgh, H. L., and Baer, S.: Death Following the Intravenous Administration of Diodrast, J.A.M.A. **118**:1051-1052 (March 28) 1942.

been attending the cardiac disease, metabolism, arthritis and allergy departments of a hospital for years. A urogram was made with the intravenous technic because of a palpable, tender right kidney. The patient had no difficulty, and nine days later a second urogram was made with the same intravenous technic. A few drops of a mixture of the aforementioned contrast medium was placed under the patient's tongue; this procedure caused no reaction. Then 25 cc. of a 35 per cent solution of the contrast medium was injected within a period of seven minutes. Five minutes later unconsciousness developed, and the patient died twenty minutes after the beginning of the injection. Goldburgh and Baer consider that her death was due to the anaphylactic reaction which followed the intravenous injection of the contrast medium. Cases occasionally are reported, of the occurrence of death after excretory urography. Study of most of these cases suggests that an anaphylactic reaction resulted. Goldburgh and Baer suggest that a detailed history with special inquiry as to allergy should be taken and that the patient's sensitivity should be tested before excretory urography is attempted.

Tzschirntsch [79] discusses injuries which can follow retrograde pyelography. He states that damage to the renal parenchyma may result from distention of the renal pelvis and also that the mucosa of the renal pelvis may be injured by the medium, either by corrosion of the mucous membrane or by resorption of the metallic elements in the solution. Injury caused by the ureteral catheter is much more frequent than injury caused by the injected solution. Tzschirntsch reports 2 cases in which injury to the calices had been inflicted by ureteral catheters. The damage was proved at operation. In both cases the mucosa of the calices was perforated by the catheter. This was followed by deposition of contrast medium in the renal parenchyma. In 1 of these cases there was evidence of sclerosis and destruction of the involved renal tissue. In the second case there was complete absorption of the injected material, but secondary renal stones developed some years later. In both cases there were typical clinical manifestations of reaction to the injection. A sharp pain occurred immediately after the injection of 2 or 3 cc. of the contrast medium and was followed by serious renal pain and infection which persisted for several weeks. According to Tzschirntsch perforations by catheters can be avoided if physicians will be careful never to use a ureteral stylet. Also, the ureteral catheter never should be passed beyond the lower part of the renal pelvis. This region can be determined by noting the markings on the catheter and by the regularity with which urine drips from the tip of the ureteral catheter.

79. Tzschirntsch, K.: Die instrumentelle Schädigung der Nieren durch die retrograde Pyelographie, Ztschr. f. Urol. **35**:69-77, 1941.

ANESTHESIA

Townsend [80] maintains that anesthesia produced with pentothal sodium has been shown to be safe as or safer than anesthesia produced with other agents when it is employed for almost all types of urologic surgery. The only contraindication would seem to be extreme youth. The careful administration of pentothal sodium is absolutely essential to satisfactory results. The advantages of anesthesia produced by pentothal sodium have been shown by use of the method in cases of respiratory diseases. He states that the dangers of explosion in the operating room are entirely eliminated when this type of anesthesia is used. It is also the most pleasant type of anesthesia from the patient's point of view.

TRANSMISSION OF GENITAL TUBERCULOSIS

Schmid [81] reports a case of transmission of tuberculosis. Six weeks after intercourse, the patient had a tuberculous ulcer of the vulva, and on examination it was found that her partner had tuberculous prostatitis and vesiculitis seminalis.

HEMATURIA

Weyeneth,[82] in discussing the differential diagnosis of hematuria, reports 2 cases in which difficulties in diagnosis were encountered. In 1 case a papilloma was situated in the upper part of the ureter; in the other a pseudocyst filled with blood was found in the capsule of a kidney. This pseudocyst apparently had developed after trauma. Treatment consisted of nephrectomy in both cases.

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80. Townsend, J. M.: The Use of Pentothal Sodium in Urological Surgery, J. Urol. **47**:235-239 (March) 1942.

81. Schmid, M.: Primäre Inokulationstuberkulose der Vulva durch Kohabitation, Schweiz. med. Wchnschr. **70**:852-853 (Sept. 7) 1940.

82. Weyeneth, R.: Diagnostic différentiel des hématuries à propos de deux cas rares, Schweiz. med. Wchnschr. **71**:481-483 (April 5); 501-505 (April 12) 1941.